SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

SEPTEMBER 1901.

GENERAL PHYSICS.

1609. *Specific Gravities of very small Masses of Solids.* **G. Guglielmo.** (N. Cimento, 1. pp. 290–294, April, 1901; Accad. Lincei, Atti, 9. 2. ser. 5. fasc. 8.)—Description of apparatus: A kind of submerged float, capable of rotating round an axis and weighted with the body to be examined. This body, being practically used as a rider, may be very small. The results are extremely accurate, especially when observations are made in two liquids of known specific gravity. A. D.

1610. *Influence of Heat on Elasticity.* **M. Rudeloff.** (Tech. Versuch. Berlin, Mitth. 18. 6. pp. 298–314, 1900.)—Exhaustive research was made on various metals (cast iron, cast steel, beaten bronze, and lead), by bending and stretching rods at various temperatures. The influence of the method of casting was also carefully noticed. Stresses were put on up to and including the breaking load. Curves and tables are given showing that most metals are as strong for small loads at fairly high temperatures as at low temperatures; but for greater loads they are much weaker. The author has constructed models in three dimensions (like those by Willard Gibbs in Thermodynamics), the axes being in this case (1) temperature; (2) load per square mm.; (3) yielding.

The research, which was conducted at the Institute in Berlin for testing metals, is purely experimental. But the curves and diagram speak for themselves. P. E. S.

1611. *Influence of Previous Physical Changes on Elasticity.* **M. Rudeloff.** (Tech. Versuch. Berlin, Mitth. Ergänzungsheft, 1. pp. 1–76, 1901.)—A very lengthy report on the elasticity of various metals, amongst which are copper, steel of various kinds, soft iron, delta-metal, manganese bronze, &c. The main object seems to have been to find the influence which bending and straightening, stretching and compressing, have on the elasticity of materials. Thus repeated stretching on the same specimen was made with intermediate examination of elasticity. Tables and curves are given in great quantity. There was also research on other points, such as (1) the influence of annealing, (2) the relation of stress to strain at various temperatures. Other researches by the same author on this subject are referred to in the preceding Abstract, and in No. 774 (1901). P. E. S.

1612. *Influence of Capillarity on the Outflow of Liquids.* **C. Christiansen.** (Ann. d. Physik, 5. 2. pp. 436–447, May 29, 1901. Translated from "Oversigt d. Kgl. Videnskabernes Selskabj Forhandlingär," No. 1, 1901.)—This is a description of interesting experiments on the efflux of liquids as influenced by capillarity, friction, &c. It is found that when the stream is changing from drops to a continuous column the rate of flow is a minimum. The influence of capillarity is shown by placing the nozzle of the discharge tube under water, when it is found that the rate of discharge is faster than in air for a small head of the liquid. It is also shown by placing the tube above ether, when the velocity of efflux is increased. The result of polarising the surfaces of separation is also studied. R. S. W.

1613. *Determination of Surface Tension at the Interface of Two Liquids.* **F. R. Watson.** (Phys. Rev. 12. pp. 257–278, May, 1901.)—A description of methods and results, the methods being based upon Rayleigh's ripple-wave method, with improvements. A. D.

1614. *Relation between the Viscosity-Parameter and other Physical Constants.* **A. Batschinski.** (Zeitschr. Phys. Chem. 37. pp. 214–216, May 17, 1901.)—If η denote the coefficient of viscosity of a non-associating liquid, the author has already found that $\eta T^3 = \text{const.} = E$; E is called the viscosity-parameter. Now Kamerlingh Onnes has deduced from the theory of corresponding states that for two liquids in corresponding states—

$$\eta_1 : \eta_2 = \frac{M_1^{\frac{1}{2}} \theta_1^{\frac{1}{2}}}{m_1^{\frac{2}{3}}} : \frac{M_2^{\frac{1}{2}} \theta_2^{\frac{1}{2}}}{m_2^{\frac{2}{3}}}$$

when M_1, M_2 are molecular weights, m_1, m_2 molecular volumes, and θ_1, θ_2 critical temperatures. Since—

$$\frac{E_1}{T_1^3} : \frac{E_2}{T_2^3} = \frac{E_1}{\theta_1^3} : \frac{E_2}{\theta_2^3},$$

it follows that the expression—

$$\frac{E}{\theta^3} \Big/ \frac{M^{\frac{1}{2}} \theta^{\frac{1}{2}}}{m^{\frac{2}{3}}} \text{ or } \frac{M^{\frac{1}{2}} \theta^{\frac{7}{2}}}{E m^{\frac{2}{3}}}$$

has the same value for every liquid. Writing instead of m the molecular refraction

$$M_R \equiv \frac{M}{\rho} \cdot \frac{n^2 - 1}{n^2 + 2}$$

it follows that

$$\frac{M^{\frac{1}{2}} \theta^{\frac{7}{2}}}{E (M_R)^{\frac{2}{3}}} = \text{const.}$$

It is found that this is actually the case, the average value of the "constant" being 39,500. The author points out that the formula may be used to calculate approximate values for the critical temperature. F. G. D.

1615. *Internal Friction in Chrome Alum Solution.* **E. Ferrero.** (N. Cimento, 1. pp. 285–287, April, 1901.)—The internal friction in solutions of chrome alum begins to fall off slightly at 55°, at which temperature the colour begins to change from violet to green (a basic salt and free acid), and continues to fall until 80°, at which temperature it becomes practically constant. The difference in friction between the violet and the green solution diminishes as the solutions are weaker. A. D.

1616. *Internal Friction of Argon.* **H. Schultze.** (Ann. d. Physik, 5. 1. pp. 140–165, May 4, 1901.)—Details are given of experimental research and results for argon containing $\frac{1}{2}$ per cent. nitrogen. At 0° C.,

$$\eta_0 = 2104 \cdot 10^{-7}\,;\ C = 169 \cdot 9\,;$$

then at absolute temperature $\tau (= t^\circ \text{ C.} + 1/a$ where a is the coefficient of expansion),

$$\eta_\tau = \eta_0 \frac{1 + aC}{1 + C/\tau} \sqrt{1 + at}.$$

This formula is based upon $\eta = 0 \cdot 30967 \rho \Omega L$ where Ω is in the arithmetical mean molecular velocity, L the mean free path, and ρ the density (O. E. Meyer, Kin. Theor. d. Gase. 2. Aufl., p. 189, 1899); $\Omega \propto \sqrt{1 + at}$; and $L_\tau = L_0(1 + aC) \div (1 + C/\tau)$ where L_0 is the mean free path at 0° C. and C a constant depending on the cohesion (Sutherland, Phil. Maga., 1893); it gives better approximations than Rayleigh's formula. A. D.

1617. *Flow of Air past Obstacles.* **Marey.** (Comptes Rendus, 132. pp. 1291–1296, June 3, 1901.)—For studying the changes in the direction and velocity at different points of a column of air which is made to flow past an obstacle of given size and shape, the author employs thin columns of smoke which are injected into the air column. The flow takes place in a box of square section (the side of the square being 50 cm.), one of whose sides consists of a sheet of glass, so that the appearance of the smoke-lines may be photographed. The air and smoke are passed through suitable filters, so that when no obstacle is interposed the smoke-lines are straight and parallel to each other; 58 smoke-lines are employed by the author. The direction of the smoke-lines gives that of the air-current at any point. In order to study changes of *velocity*, the author adopts the ingenious expedient of throwing the series of small tubes through which the smoke is injected into lateral vibration by means of an electric trembler of known frequency. The effect is to produce sinuosities in the smoke-lines. These sinuosities are equi-distant, so long as the velocity along a given line is constant. If the velocity varies, its variation is deducible from the changes in the intervals between consecutive sinuosities. Samples of photographic records obtained by the author illustrate the paper. A. H.

1618. *Distribution of Molecular Energy.* **J. H. Jeans.** (Roy. Soc., Phil. Trans. 196. pp. 397–430, May 22, 1901.)—The author considers the difficulty to which the Maxwell-Boltzmann theory of gases leads in relation to the specific heats of substances. If the mean kinetic energy is the same for each degree of freedom, results follow which are irreconcilable with experiment. But the author remarks that Boltzmann's law of distribution of energy is proved to be the necessary law only if certain conditions postulated by Boltzmann are fulfilled. It fails altogether if there be dissipation, even though the conditions in other respects are fulfilled. There is dissipation if we admit any interaction, however small, between molecules and the surrounding ether. That such interaction exists is proved by the phenomena of radiation.

In the present paper the author confines himself to two forms of molecule, of which the first is the smooth loaded sphere referred to in Boltzmann's Vorlesungen, part ii. p. 129. This had been (but for an oversight) effectively treated by Burnside. The author assumes here the usual condition postulated by Boltzmann, viz., the independence of the velocities of the spheres. If there be no dissipation we have all Boltzmann's conditions, and obtain, as others have obtained, Boltzmann's result, the equal partition of energy among the degrees of freedom. The author also shows the rate of approach to this final state, namely, if H be the energy of rotation (2 degrees of freedom), K that of translation (3 degrees), then as the result of collisions—

$$\frac{d\mathrm{H}}{dt} = -\beta\rho\sqrt{\mathrm{K}}(\mathrm{H} - \tfrac{2}{3}\mathrm{K}),$$

where ρ is the density, and β is a constant independent of the law of distribution. If the rotation be retarded by friction with ether, we have dissipation. Let w be the angular velocity, ϵw the rate of its retardation. Then the conditions for an approximately steady state are found to be that ϵ and β should be small, and $\epsilon\beta\sqrt{\mathrm{K}}$ very great. Next we may suppose a molecule having many degrees of internal freedom. If we postulate with Boltzmann the independence of the velocities, then in the absence of dissipation we have all Boltzmann's conditions and his result. Also equations are obtained analogous to those above given. If there be dissipation, the co-ordinates may be divided into classes, according as the corresponding velocities are or are not retarded by friction. It is then found that the degrees of freedom require to be weighted as well as counted.

In Part II. the author comes to a more general type of molecule—namely, a molecule is a dynamical system, having $k + n$ degrees of freedom of internal motion, there being k co-ordinates $r_1 \ldots r_k$ which occur in the potential, and n, namely $p_1 \ldots p_n$, which do not. The corresponding velocities are $s_1 \ldots s_k$ and $q_1 \ldots q_n$. They are normal co-ordinates, so that the kinetic and potential energies are the sums of squares. Also the oscillations of the r's are assumed to be so small as to be isochronous. It is assumed that as regards the translations, Boltzmann's conditions prevail, the permanent state being denoted by $\phi(u, v, w) = \epsilon^{-h(mc^2 + 2\psi)}$, where ψ is a potential.

A distinction is drawn between encounters and collisions. So long, however, as there is no dissipation, the author's treatment does not differ in essentials from those of other writers on the subject, and he obtains, therefore, the usual result, that the Maxwell-Boltzmann distribution, or equal partition of energy, is in the steady state permanent, necessarily dependent as it is on the acceptance of Boltzmann's postulates.

But the author again introduces a dissipation function, expressing interaction of matter and ether, or radiation, and again it is found that the equal partition disappears. The degrees of freedom must be weighted as well as counted. A special solution is found for low temperatures, *i.e.*, below that of incandescence, on the hypothesis that by some external agency energy lost by radiation is restored to the body.

In Part III. are considered certain physical consequences of the theory. First, it is shown how if the main transfer of energy take place through collisions, the radiation may be a function of the temperature. A generalised theory of temperature is then given according to which a gas has a *principal temperature* T, corresponding to the mean kinetic energy of translation of its molecules, and subsidiary temperatures τ_1, τ_2, &c., corresponding to the mean energy of the several modes of vibration. At infinite temperatures these become equal to T; at temperatures below that of incandescence they are small compared with T. But the subsidiary temperatures may be influenced by chemical action. Also by the passage of light, certain modes of vibration may be much increased in energy, giving rise to a bright band in the spectrum. It is found that the second law of thermodynamics will not generally hold for a gas emitting radiation. S. H. B.

1619. *The Boomerang.* **G. T. Walker.** (Phys. Zeitschr. 2. pp. 457–461, May 4, 1901.)—Among the many often accidental varieties of boomerangs, the author distinguishes two types. In the one the two arms of the boomerang meet under an angle which is not much larger than a right-angle, and are twisted in the sense of a right-handed screw. The other type, more obtuse and generally shorter, corresponds to a left-handed screw. With the former, most peculiarly complex curves can be described ; the latter rises in a fairly straight line and returns nearly on the same path. To increase the inertia of the missile, the author wound copper-wire round the middle and both ends. (Translation in *Nature*, pp. 338–340, Aug. 1, 1901.) H. B.

1620. *Equilibrium Forms of Powdered Masses.* **F. Auerbach.** (Ann. d. Physik, 5. 1. pp. 170–219, May 4, 1901.)—The experiments were made with grains of sand, limestone, glass, lead, various seeds, &c., not less than 0·01 cm. in diameter, heaped up by four methods : (1) The powder was poured on the base ; (2) the base was held a little above a table which, along with the base, was covered with the powder, and a small instrument was then gently applied to the edges of the base ; (3) the base rested on the table which was all covered with material, and was then lifted ; or (4) the table was lowered. Bases of various forms were applied. When the powder is heaped up in the corner, formed by two walls of unlimited length at right angles to one another, the normal slope is plane, curved over, however, towards either plane. Convexity of the horizontal section diminishes the slope, concavity increases it. The figures over polygons as bases are pyramids with rounded-off edges and points ; this rounding-off is least for triangles and is proportional to the size of the grain. Over a circular base, an hyperboloid of revolution is formed ; the hollow, formed by the inner ring wall when a circular hole is made in the base, is also an hyperboloid of revolution. The normal slope varies between 21° and 36° ; it is the greater, the smaller, lighter, rougher, and less round the grains, and may assume any value between 0° (apex of the rounded-off cones) and 90° (over small holes). The author discusses the theory and shows that it is confirmed by his experiments. H. B.

1621. *Gravitational and Magnetic Fields.* **R. Eötvös.** (International Physical Congress at Paris, Report, 3. pp. 371–393, 1900.)—By a torsion balance method the author determines the derivatives of the components of gravity in the neighbourhood of a point, thus finding the curvature of the equi-gravitational surface at that point, the curvature of the line of force, the tangent to the equi-gravitational curve, and the gradient of variation of the gravitational force. These data give indications as to the probable distribution of masses causing these variations. The method is exceedingly sensitive, and gives indications of underground rocks and their distribution : it is far more sensitive than any pendulum method. Bessel's conclusion that attraction was independent of the nature of the attracting masses to within $\frac{1}{1000000}$ has been pushed very much farther. The sun's attraction is not modified one hundred-millionth part by the interposition of 1 km. thickness of the earth's crust. Similar methods have been applied to the exploration of magnetic fields. A. D.

1622. *Thermal Deformation of a Balance.* **W. Felgentraeger.** (Ann. d. Physik, 5. 1. pp. 234–235, May 4, 1901.)—In reply to the contention of Middel [see Abstract No. 1395 (1900)] that the balance used for determining the density of the earth is deformed owing to the unequal expansion of rolled and cast brass, the author maintains that a much more likely explanation of the variation of sensitiveness may be based upon the difference in expansion of the brass beam and the steel knife-edges. He shows by calculation that the difference indicated by theory is in practical agreement with the observed variation. E. E. F.

1623. *Relations between Earthquakes and Detonations.* **J. Knett.** (Akad. Wiss. Wien, Sitz. Ber. 109. I. pp. 700–734, 1900. Report of the Earthquake Commission of the Academy.)—Although the precursory waves which cause the tremor, the first indication of a distant earthquake, are as a rule also the carriers of the noises which accompany the earthquake, the detonations are sometimes out of all proportion to the mechanical concussion and must be independent acoustical phenomena. The detonations appear to be propagated, not by the preliminary tremor, but by the main waves, and their intensity accords generally with the surface concussion. But we have very little experimental material concerning the observation of submarine explosions at a distance. Detonations might be caused by an outburst of a large volume of confined gas and a breakdown of natural or artificial cavities.

H. B.

1624. *Detonations in the Duppan Mountains, Aug.* 14, 1899. **J. Knett.** (Akad. Wiss. Wien, Sitz. Ber. 109. I. pp. 735–767, 1900. Report of the Earthquake Commission of the Academy.)—The locality is east of Karlsbad, the ground basalt and basaltic tuffa, overlying granite. Two detonations were heard, the second one feeble, and two tremors were felt, the second one very weak. The data are very scanty. The phenomena were chiefly noticed in a circle, about 13 km. in diameter, and to the north of it, not to the south. The disturbance was not felt at the epicentre, and originated probably at a depth of 9 km. The impulse seems to have been directed N.N.E. and struck the surface a little to the north of the epicentre. Allusion is made to refraction of the waves in strata of different densities. The cause of the phenomenon was possibly an outbreak of carbon dioxide gas. H. B.

1625. *Volatile Gases in Atmospheric Air.* **G. D. Liveing** and **J. Dewar.** (Roy. Soc., Proc. 67. pp. 467–474, Feb. 5, 1901; also Cambridge Phil. Soc., Proc. 11. pp. 107–8, April 22, 1901.)—By a special process [Abstract No. 592 (1899)], tubes were filled with the more volatile gases of the atmosphere which were not condensed at the temperature of liquid hydrogen, and these tubes containing the residue of uncondensed atmospheric gases were examined spectroscopically. In the spark spectra obtained strong rays in the red, orange, and yellow are attributed to hydrogen, helium, and neon; but other lines appear in the photographic record of the spectrum which seem to be due to unknown substances. As the mixture of gases probably included some of all such gases as pervade interplanetary and interstellar space, search was made in their spectra for the prominent nebular, coronal, and auroral rays. Although the residual gases of the atmosphere uncondensed at the temperature of liquid hydrogen do not show the nebular lines, it was found that another tube gave a ray very close indeed to the green nebular ray, and appearances seem to indicate that the substance which is luminous in nebulæ may be really present in the earth's atmosphere. Faint rays were also observed whose positions correspond approximately to the stronger rays in N. Lockyer's list of coronal lines. With regard to these questions and also to the possible occurrence of auroral rays in the spectra of the gases, the authors intend to carry out farther investigations. Photographs of the ultra-violet rays were obtained by a quartz-calcite train of prisms, but the rays had to pass through the glass of the containing tube. A list of the approximate wave-lengths of the rays, visible and ultra-violet, observed about the negative pole, is given. J. J. S.

1626. *Enhanced Lines in the Spectrum of the Chromosphere.* **J. N. Lockyer** and **F. E. Baxandall.** (Roy. Soc., Proc. 68. pp. 178–188, May 23, 1901.)—This paper is essentially a reply to the report of the results obtained by the Yerkes Observatory party during the eclipse of May 28, 1900. In this report Frost concludes from a discussion of the lines photographed and their origins that the "enhanced lines" of the various elements concerned do not appear to occur in any systematic manner among the bright chromospheric lines. The authors of the present paper show conclusively that this reasoning is doubtful, obtained probably by the selection of the origins from coincidences in wave-length with the Fraunhofer lines in Rowland's table of solar spectrum standard lines. If the lines are discussed according to their relative intensity, it is seen from the tables provided in the paper that 80 per cent. of the enhanced lines of titanium alone agree with eclipse lines within 0·3 tenth metre. Further tables support the same conclusion by giving a summary of Hasselberg's *arc* lines, from which it is seen that these are not prominently represented. The question is also discussed in relation to the lines of iron. C. P. B.

1627. *Wedge Photometer applied to Measurement of Photographic Magnitudes of Stars.* **B. Baillaud.** (Comptes Rendus, 132. pp. 1091–1094, May 6, 1901.) —By arranging for suitable illumination of the background, the wedge photometer can be used to extinguish the dark images of stars on negatives, just as it is used to extinguish the bright images of stars in the focal plane of an ordinary telescope. The writer has constructed an apparatus for the purpose, a description of which will, he says, be given elsewhere. The registration is mechanical. The present paper explains how the scale was graduated, and tested by observations of known stars. The question is complicated by the fact that for a constant dark image on a variable bright background the extinction readings are not proportional to the logarithm of the brightness of the star, as is the case for a bright star on a dark ground. There is further difficulty owing to the size of the images of brighter stars. Results of observations so far have been satisfactory. It was noted that multiplying the time of exposure by 3·1 altered the images of all stars by one magnitude. A. E.

REFERENCES.

1628. *Muscular Energy.* **A. Chauveau.** (Comptes Rendus, 132. pp. 938–944, April 22, 1901.)—Further particulars of the work referred to in Abstract No. 754 (1901). H. B.

1629. *Atmospheric Radiation.* **W. Hallock.** (Amer. Journ. Sci. 11. pp. 230–234, March, 1901.)—Comments on F. W. Very's paper [Abstract No. 344 (1901)]. H. B.

LIGHT.

1630. *Propagation of Cusped Waves, and their Relation to the Primary and Secondary Focal Lines.* **R. W. Wood.** (Phil. Mag. 1. pp. 589–593, May, 1901. Paper read before the Phys. Soc. of London.)—This article is a sequel to a former paper (Phil. Mag. July, 1900, p. 148), without reference to which it will be found difficult to follow. The case of reflection of a plane wave by a hemispherical mirror is here further dealt with. The reflected wave, as previously shown, is cusped, the locus of the cusps being the caustic. The wave has something of the form of a volcanic cone with a crater, and the author shows that the outer wall of the "volcanic cone," before it crosses the axis of the mirror, represents the portion of the wave-front between the primary and secondary focal lines. While the "crater" is concave along every meridian, the outer wall is saddle-shaped, being convex along one meridian, and concave along the meridian at right angles to it. On inspecting the diagram usually given to illustrate the formation of focal lines, it will be seen that the wave-front between the two focal lines has this required saddle-shape. The author has made a model of the wave-front by softening a wide, thin tube, sucking in the closed end, and widening the open end. Another simple piece of apparatus for teaching purposes can be made by silvering the outside of a hemispherical glass dish, placing it on a stand, and arranging a two-candle electric lamp to move along the axis, the reflected rays being received on a piece of ground glass. An error sometimes made is pointed out, namely, the assumption—say in the case of a spherical wave refracted at a plane surface—that the wave-fronts are hyperboloids in the second medium, because the caustic is the evolute of a hyperboloid. The correct statement is that they are the parallels to a hyperboloid. A. E.

1631. *Microphotometer for measuring Absorption of Light.* **J. Koenigsberger.** (Zeitschr. Instrumentenk. 21. pp. 129–133, May, 1901.)—The instrument is only adapted for the visible spectrum. The following advantages are aimed at in the construction: (1) High degree of accuracy in a single measure; (2) possibility of determining absorption of very small portions, (⅓ to 1 sq. mm.) of the material examined, (solid substances, except glass, not being truly homogeneous in large masses); (3) adaptability for light of any degree of homogeneity. A diaphragm with two equal rectangular openings of 3 × 5 mm., 1 mm. apart, is placed under a rhomb of calcspar 24 mm. in height, cut with its faces at 55° to the optic axis, and both are placed under the microscope. Owing to double refraction, four images of the two holes are formed by the objective, the two central images partly overlapping. Only these two are seen by the observer, as a diaphragm at the focus of the eye-glass cuts off all the rest of the field. The light is so arranged that, when nothing is in the way, both holes are equally illuminated, and the two images therefore receive equal quantities of light polarised in different directions. If now an absorbing medium be placed below one hole, then the amount of light polarised in one direction exceeds that polarised in the other. This is betrayed by the appearance of bands produced by a Savart's polariscope (see below). The light entering the second hole is then weakened, by means permitting of measurement, until the disappearance of the bands shows that the two quantities of polarised light are again equal. This is done either by sliding a graduated wedge, or rotating a Nicol with divided circle attached, below the hole. The Savart's plate, consisting of two crossed plates of calcspar, 5 mm. thick, cut at 45°, is placed above the microscope objective, either in the objective itself, or in a separate revolving ring. A fixed Nicol is inserted in the tube between the ocular and the plate. The microscope objective is an achromatic lens of 6 to 9 cm. focus. A little telescope adjusted for infinity, with objective of 5 cm. focus, serves as ocular. The sensitiveness of the apparatus is due to the easy visibility of the bands. Heightened effect, owing to contrast, is produced by covering half of each hole with a piece of cover glass. The author states that results of numerous trials show the performance of the apparatus to be at least equal to that of the best photometers hitherto in use. The discrepancies for blue and violet were much larger than for other colours—a result not accounted for by their weaker intensity, since measures with strong illumination were no better than with weak. The author thinks the difference must have a physiological origin, and wonders whether other observers have had a similar experience. A diagram illustrating the principle of the apparatus was given in a previous number (Ibid. 21. p. 59, 1901); a sketch of a later form accompanies this paper. A. E.

1632. *Determination of Wedge-Constant of Stellar Photometer.* **J. A. Parkhurst.** (Astrophys. Journ. 13. pp. 249–259, May, 1901.)—E. C. Pickering, of Harvard College Observatory, has organised a co-operative system of determinations of faint stellar magnitudes, and the present paper deals with the investigation of the constants, &c., of the instrument sent to the Yerkes Observatory for the furtherance of this work. Sectional drawings and photographs of the instrument are given to show its construction. The light from an artificial source is passed through a small aperture and then reflected from *both* surfaces of a plane-parallel glass plate into the ocular, forming *two* images of the artificial comparison source. The image of the real star is then brought between these, and the light from the artificial source is varied in intensity by a movable interposed photographic wedge until equality is obtained with the real star.

Particulars are given of the calibration of the wedge by the "revolving wheel" method, in which the light can be reduced by known amounts. Tables are given showing relation of determined magnitudes to those of other institutions. C. P. B.

1633. *Relative Brightness of Sun and Sky.* **Q. Majorana.** (Phil. Mag. 1. pp. 555–562, May, 1901. Translated from Accad. Lincei, Atti, 9. Aug. 5, 1900.)—The apparatus used is small and easily portable. Two tubes, T_1 and T_2, intended to be turned towards sun and sky respectively, revolve independently at right angles about a third tube T_3, which serves as ocular tube. Rays passing down T_1 and T_2 are reflected up T_3 by mirrors at 45°, the mirror nearer the eye having a hole in it to let the rays from T_1 pass through. The whole is mounted on a ball-and-socket joint. T_1, the solar tube, has at its end a diaphragm with a small hole, behind which is a short-focus lens. The sky tube, T_2, is completely open at the end, but has an iris diaphragm, D, at its centre. In both tubes the light passes through two ground-glass screens. The eye by means of the ocular tube sees an azure field illuminated by the sky, and in its centre a white or reddish spot due to the sun. The aperture of D is adjusted so as to give equal illumination of the two areas. The instrument was calibrated by artificial light. Observations were made at Rome and Catania. The luminosity of the sky varies from point to point. Thus on an

August day at 11 a.m. the following values were found for r, the ratio of the sun's brightness to that of the sky:—close to sun 357,000, 90° from sun 950,000, horizon 98,000, white cloud 18,000. "The variations are evidently due for the most part to the presence of aqueous vapour." The luminosity also varies during the day. Observations made during seven hours on one day in August gave, at 90° from the sun, values of r varying from 175,000 at 6 a.m., up to 950,000 at noon, and down again to 225,000 at 6 p.m. But the figures change considerably with altitude. On the summit of Etna (2,942 m.) r was found to have sensibly the same value for all regions except those close to the horizon, and to be about five times greater than at Catania. On a very clear day r was 2,570,000 at 5.50 a.m., and 3,760,000 at 11 a.m. Almost simultaneously Sella on Monte Rosa found values of r about 5,000,000. Hygrometric observations were taken, but no relation was found between humidity and relative brightness. A. E.

1634. *Measurement of the Action of Light on Photographic Plates.* **F. F. Martens** and **F. J. Micheli.** (Archives des Sciences, 11. pp. 472–487, May, 1901.)—The authors describe an instrument designed by them for measuring the opacity of photographic plates. The instrument is fixed on a box having a hole in the cover, over which is placed the plate; from the side of the box projects horizontally a tube closed with an opal glass, before which is placed a lamp. The rays from this follow two paths, either going into the box and being reflected vertically upwards by a prism through the plate, or passing along a tube above the plate and being reflected upwards by a second prism. The two rays, one having traversed the plate, are collected by a lens, then pass through in succession an objective, a double-refracting Wollaston prism, a double prism, a Nicol, and an eyepiece. The prisms are arranged so that half the field of the eyepiece is illuminated by one set of rays and the other half by the other set, the two sets of rays being polarised perpendicularly. The two fields are made equally bright by rotating the Nicol, which is provided with a pointer and scale.

If a and a' are the angles of rotation of the Nicol for two plates, transmitting light of intensities J and J′, $J/J' = \tan^2 a'/\tan^2 a$. If Jf, Jd, and Je refer to plates respectively (1) fixed without exposure, (2) developed and fixed without exposure, and (3) exposed, developed, and fixed, the authors define as absolute blackening in per cent., $100\frac{Jf-Je}{Jf}$, as absolute density, $\log\frac{Jf}{Je}$, as relative blackening, $100\frac{Jd-Je}{Jd}$, and relative density $2-\log\frac{Jd}{Je}$; multiplying the latter quantity by 0·0115, gives the quantity of silver deposited per 100 sq. cm. due to the action of the light. The authors give two curves between the relative blackening and the illumination in candle-metre seconds, one curve for constant time of exposure with constant light at varying distances, the other for constant candle-metres and varying time of exposure. The slight difference between the two curves is attributed to inequalities in the gelatine or development. G. H. B.

1635. *Differential Double Refraction.* **E. J. Rendtorff.** (Phil. Mag. 1. pp. 539–548, May, 1901.)—Crystal plates were compared to test their suitability for achromatic combinations, such as quarter-wave plates. The method was similar to that used by D. B. Brace. [See Abstract No. 58 (1900).] Each crystal plate was in the form of a double wedge, to permit of the thickness being altered. This plate was placed between crossed Nicols so that the principal axis was at 45° to the plane of polarisation, and was examined with a spectroscope. Under such circumstances the spectrum is seen crossed by a series of black interference bands, which move along as the thickness of the crystal is changed. The order N of the plate is found from the formula $N = mn/(1 - n)$, m being the number of bands which have passed, say, the D line, and n the ratio of the initial to the final number of bands between two given wave-lengths. For comparison of a pair of crystals the apparatus was arranged so that the two interference spectra were seen in contiguity in the telescope. The thicknesses were then varied until the best coincidence of the bands was obtained in the part of the spectrum which it was desired to achromatise, when the orders were found by help of the above formula. For higher orders plane plates were used in conjunction with the double wedges. The crystals examined were Iceland spar, quartz, selenite, and mica. Mica and selenite, as well as Iceland spar and quartz, give a good coincidence of bands throughout the spectrum; with other combinations it was possible to achromatise for certain portions only. The best coincidences with sodium light were obtained with the following combinations: Mica order 40 + selenite order 35, mica 45 + quartz 40, quartz 222 + Iceland spar 212, selenite 210 + quartz 594. One of the diagrams shows the relative positions of the bands in the spectrum for selenite and quartz. The orders 67 selenite and 66 quartz give good coincidence in the most intense region of the spectrum.

D. B. Brace, in a note, remarks that "in this method of determining the order of crystal plates no error is ordinarily possible, it being merely a matter of counting." Previous methods have entailed inaccuracies, and tables of indices must therefore be erroneous to some extent. Corrected data are being tabulated. He discusses Dupet's determinations of the optical constants of selenite. A. E.

1636. *Cyanin Prisms and Anomalous Dispersion.* **R. W. Wood.** (Phil. Mag. 1. pp. 624–627, June, 1901. Paper read before the Physical Society of London.)—The cyanin used by the author in former experiments was so opaque that it did not allow of prisms being used of greater angle than 20 or 30 minutes. [See Abstract No. 791 (1901).] With a new sample of the dye which is much more transparent, prisms have been prepared of one degree refracting angle, and these transmit the green light better than the former ones. The spectrum of an incandescent lamp filament viewed through the prism is anomalous, the order of the colours being green, blue, violet, red, and orange. Combining one of these prisms with a diffraction grating enables the curves of dispersions to be beautifully demonstrated. J. B. H.

1637. *Mica Echelon Grating.* **R. W. Wood.** (Phil. Mag. 1. pp. 627–629, June, 1901. Paper read before Physical Society of London.)—The author has succeeded in making an echelon grating with only laboratory appliances, the plates being composed of thin sheets of selected mica. The sheets were examined with the interferometer, and the most suitable cut up into rectangular pieces. The retardation of each was about 50 wave-lengths for sodium light. The grating space was 0·5 mm., nine plates being used, giving a resolving power of about 500. The apparatus is of special use for class demonstration in being intermediate in power between the ordinary grating and the full-strength echelon. C. P. B.

1638. *Spark Spectra without Air Lines.* **A. Miethe.** (Phys. Zeitschr. 2. pp. 267–268, Feb. 2, 1901.)—An apparatus, with diagram, is described which is designed to give spark spectra in air which are free from air lines, it having been found that with suitable self-induction a spark at break has a spectrum in which the lines due to air are absent. The spark is made between a fixed and a movable electrode in the circuit of a battery and self-induction coil. The movable electrode is attached to a spring set in vibration by means of the hammer interrupter of a coil with iron core worked by another battery. The spectrum of radium was examined by means of the apparatus, the radium being obtained by repeated fractional crystallisation of active barium bromide by Giesel's method. The radium spectrum contained, besides lines due to barium and faint platinum lines, some calcium lines in the blue violet. A large number of radium lines were found between the wave-lengths 500–700. A Curie preparation of radium gave a spectrum which coincided with the first, as regards the position but not the intensity of the lines. G. E. A.

1639. *Banded Spectra of Alumina and Nitrogen.* **G. Berndt.** (Ann. d. Physik, 4. 4. pp. 788–795, April, 1901.)—Experiments were made to determine whether the banded spectrum of aluminium was due to metallic aluminium or its oxide. The conclusion of the author is that for the production of the banded spectrum the presence of oxygen is always necessary, and that the spectrum is in reality that of alumina. The spectrum of nitrogen is also considered, and as an appendix to the paper an elaborate list of the wave-lengths of the lines in the band spectrum of nitrogen is given. J. J. S.

1640. *Wave-lengths of some Iron Rays.* **C. Fabry** and **A. Perot.** (Comptes Rendus, 132. pp. 1264–1266, May 28, 1901.) — Wave-lengths measured [see Abstract No. 69 (1901)]; values found, in arc-light, are as follows: 649·4992, 623·0733, 606·5489, 576·3023, 561·5657, 558·6775, 550·6783, 543·4525, 530·2321, 528·2954, 508·3345, 500·1887, 485·9763, and 473·6785. A. D.

1641. *Constitution of a Luminous Gas.* **J. J. Thomson.** (Archives Néerlandaises, 5. pp. 642–643, 1900.)—The refractive index μ of a gas for light whose vibration-frequency is p was shown by Lorentz to be given by the equation :—

$$\frac{\mu^2-1}{\mu^2+2}=\frac{4\pi}{3}\Sigma\frac{Ne^2V_0^2}{m(n^2-p^2)}\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where e is the charge and m the mass of an ion; n the frequency of a free vibration, N the number of ions vibrating with this frequency, V_0 the velocity of light in a vacuum, the summation being taken for all the modes of vibration of the molecule, *i.e.*, for all the lines in the spectrum of the gas. For very long waves p is approximately zero, and $\tau\mu^2=K$, the specific inductive capacity of the gas. If λ is the wave-length corresponding to the frequency n, then $v/n=\lambda/2\pi$ and equation (1) becomes—

$$K-1=\Sigma\frac{Ne^2}{4\pi m}\lambda^2\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

In the denominator of the left-hand side of equation (2), $K+2$ has been put equal to 3, as K for all gases is approximately unity.

From the spectrum of the gas the various values of λ can be determined, and if it be assumed that all the molecules can give out the vibration whose wave-length is λ, Ne can be found. If the vibrating ion is negatively charged, $e/m = 10^7$. Applying this formula to some gas, *e.g.*, helium, each line in the spectrum will contribute to the right-hand side of equation (2), so that if only one line is taken into account the estimated value of $K - 1$ ought to be too small. Supposing all the molecules of helium to be giving out the yellow line $\lambda = 5{\cdot}9 \times 10^{-5}$, N being the number of molecules in 1 c.c. of any gas at atmospheric pressure and temperature, and e having the smallest possible value, viz., the charge on the H ion in the electrolysis of solutions (e being measured in electromagnetic units), since one unit liberates 1·23 c.c. of hydrogen, $Ne = 0{\cdot}4$. Putting in these values and taking account of the yellow line only, $K - 1$ from equation (2) would be $1{\cdot}1 \times 10^{-3}$; the actual value is $8{\cdot}5 \times 10^{-5}$. Thus the calculated value is thirteen times the real value and only one of the lines of helium has been taken into account. In the case of the gases tried, the value of $K - 1$ obtained from equation (2) is found to be enormously too large if it is assumed that every molecule of the gas can give out every line in the spectrum. This suggests that in a luminous gas the spectral lines are not given out by every molecule of the gas, but by only a comparatively small number of systems formed in some way out of the molecules, perhaps by aggregations of greater complexity than the molecules. The systems which give out one line may be different from those giving out the others. This would afford an explanation of the extraordinary variations which sometimes take place in the relative brightness of the lines given out by a gas when the circumstances are changed. The number of lines in the spectrum of a gas may not be necessarily connected with the number of degrees of freedom of the average molecule—a result which is of some importance in connection with the theory of the ratio of the specific heats.

J. J. S.

1642. *Direct Production of Röntgen Rays in Air.* **A. Nodon.** (Comptes Rendus, 132. pp. 770–772, March 25, 1901.)—Experiment shows that Röntgen rays may be produced directly in air, and outside the Crookes vacuum. They are produced under the simultaneous action of ultra-violet rays and of an electric field. If an electric field is set up between the plates of an air condenser and a pencil of ultra-violet rays is directed on to one of the plates, Röntgen rays are produced. These Röntgen rays are propagated along the same direction as the lines of electric force of the field. They are not emitted in other directions. They possess greater activity when the direction of the lines of force of the field is the same as that of the propagation of the ultra-violet radiation, that is when the illuminated plate of the condenser is the negative one. The activity of the emitted Röntgen rays is a function: (1) of the intensity of the electric field; (2) of the intensity of the ultra-violet radiation; (3) of the wave-length of the latter; (4) of the nature of the substances at whose surface they originate. The general properties of the Röntgen rays produced directly in air are indentical with those of the X-rays produced by means of the Crookes tubes. They discharge electrified bodies after their passage across aluminium, and in various ways their action corresponds to that of Röntgen rays otherwise produced. J. J. S.

1643. *Röntgenised Gases.* **E. Villari.** (International Physical Congress at Paris, Report, 3. pp. 152–168, 1900.)—Röntgenised air and gases are deprived of their power of dissipating electric charges when they are sent through an ozonator in action, or through the same ozonator for some time after the current actuating it has been broken, this time in the latter case being longer the longer the time for which the actuating current has been kept up. The ozonator becomes charged with two kinds of electricity; and it may be partially discharged and its neutralising power diminished by reversing the actuating current. The charges in the ozonator, in neutralising the Röntgenised air, neutralise each other or disappear in transforming Röntgenised into ordinary air. Gases become able to discharge electrified bodies if long inductor sparks be sent through them, the more so the longer the sparks within certain limits; and they retain this property for some time and even after passing through glass or metal tubes several metres long and 2 cm. in diameter. An ozonator will undo this effect produced by sparks and will go on doing so for some time after the current actuating it has ceased. The discharging power of products of combustion is only partly taken away by cooling, but is entirely so by an ozonator in action; but the effect of the ozonator rapidly falls off when its actuating current ceases. A tube charged positively or negatively will deprive Röntgenised air of its discharging power; but the tube very slowly loses its charge, and along with this its power of neutralising Röntgenised air. Röntgenised air behaves as an actual conductor of electricity; but there appears to be no increase in its thermal conductivity. Röntgenised air loses its discharging power by friction; and on being passed through bent tubes it does so much more rapidly than when passed through the same tubes straight; the material of the tube seems to make no difference. Electric charges can be developed by the impact of Röntgenised air on large surfaces, metallic or non-metallic. The sign of the charges does not depend on the nature of the metal employed but on the condition of friction; if the Röntgenised air pass quickly and lightly over metallic surfaces these are charged negatively, if slowly and under more pressure then positively. The air ought perhaps to acquire an opposite charge: but it seems that the contrary is the case, the opposite charge being possibly absorbed in effecting the transformation from Röntgenised into ordinary air. A. D.

1644. *Negative Electrification of Secondary Rays.* **P. Curie** and **G. Sagnac.** (Soc. Franç. Phys., Bull. 165. pp. 4–5, 1901.)—While Röntgen rays do not appear to be electrically charged, the secondary rays excited by the impact of the Röntgen rays on zinc, tin, and platinum carry a negative flux of the order of 10^{-10} ampere; those from aluminium do not do so, and are otherwise much like the Röntgen rays from which they originate; while those from Zn, Sn, and Pt are much more easily absorbed than the corresponding Röntgen rays. Correspondingly, the rays from Al do not, while those from Pb and Pt do, contain radiations deviable by the magnet in addition to those not deviable (Dorn). The metal from which secondary rays have carried a negative charge acquires a positive charge. That the charged component of the secondary radiations should be deviable by the magnet is in accord with the analogy between secondary rays and radio-active rays pointed out by Mme. Curie, and with the analogy between Röntgen rays and ultra-violet light which can cause kathode discharges. A. D.

1645. *De-ionisation of Air.* **E. Villari.** (Phil. Mag. 1. pp. 535–538, May, 1901. Paper read before the Phys. Soc. of London.)—Air ionised by Röntgen rays is here passed into metallic filters of various kinds, and the charge given to the filter is measured as well as the charge remaining on the air. The filters used consisted of tubes carefully insulated and filled with metal in the form of rolled sheet, rolled gauze, filings, or wire. In some experiments the sign of the charge on the filter was positive while in others it was negative.

The difference was finally traced to the force of impact of the air particles on the metal in the filters, a reversal of sign taking place in some filters according as the air was blown more or less gently through the cylinder.

The air after passing through the filters had not lost all its discharging properties and had a small charge of the same sign as that on the filters.

J. B. H.

1646. *Conductivity of Gases under Becquerel Rays.* **R. J. Strutt.** (Roy. Soc., Phil.. Trans. 196. pp. 507–527, June 8, 1901. Abstract in Roy. Soc., Proc. 68. pp. 126–128, May 4, 1901.)—The author describes experiments on the conductivities produced in different rarefied gases by radiations from various radio-active substances. The method adopted was to measure the rate of leakage from a charged plate through the gas exposed to radiation to a parallel insulated plate connected to the insulated quadrants of an electrometer. The special arrangements are described. The radio-active substances used gave respectively radium radiation, polonium radiation, and uranium radiation. Radium gives two distinct kinds of rays, one easily absorbed by gases and solids and not deflected by magnetic force, the other more penetrating and deflectable by the magnet. Both kinds were investigated. Uranium also gives these two types, but as only a very small fraction of the total conductivity is due in this case to the penetrating type, only the absorbable rays have been investigated. The results are given in a table, which may be usefully reproduced here, especially as it includes, for comparison, J. J. Thomson's and Perrin's results for conductivities under Röntgen rays, and McClelland's results for kathode rays. The two columns for polonium refer to two different preparations, the second giving more powerful radiation than the first. In these experiments air is taken as the standard.

Gas.	Relative density.	Relative conductivity.							
		Röntgen rays.		Kathode rays.	Radium rays.		Polonium rays.		Uranium rays.
		J. J. Thomson.	Perrin.		Penetrating type.	Absorbable type.	I.	II.	
Hydrogen	0·0693	0·33	0·026	0·069	0·157	0·218	0·226	0·219	0·213
Air......	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00	1·00
Oxygen	1·11	—	—	1·106	1·21	—	1·16	—	—
Hydrochloric acid	1·27	8·9	8	—	1·46?	—	—	—	—
Carbonic acid..	1·53	1·4	1·34	1·53	1·57	—	1·54	—	—
Cyanogen	1·86	1·05	—	—	1·86	—	1·94	—	—
Sulphur dioxide......	2·19	6·4	6	—	2·32	1·93	2·04	2·03	2·08
Chloroform....	4·32	—	—	—	4·89	—	4·44	—	—
Methyl iodide	5·05	—	—	—	5·18	3·74	3·51	3·47	3·55
Carbon tetrachloride	5·31	—	—	—	5·83	—	5·34	—	—

In the case of the penetrating type of Becquerel rays, these results show that the relative conductivity of gases is mainly dependent upon their densities. McClelland's results show this same proportionality in the case of kathode rays. These penetrating Becquerel rays are now generally considered to consist of a stream of negatively charged ions travelling with enormous velocities, and the author now suggests that the absorbable rays may consist of a stream of positive ions. As the positive ions, though carrying the same charge, have an enormously greater mass than the negative ions, this theory would explain the want of penetration of these rays, and also the fact that they are less easily deflected; but it would be worth while to see if they suffer deflection in a very powerful field. W. C. H.

1647. *Thermo-luminescence by Radium Rays.* **E. Wiedemann.** (Phys. Zeitschr. 2. p. 269, Feb. 2, 1901.)—This has been shown for uranium rays by Borgmann, and H. Becquerel has shown that thermo-luminescence of fluorspar may be induced by radium. The present notice describes how the effect may be made visible for a lecture experiment. The radium preparation is placed in a hollow glass plate and covered with aluminium. The luminescent substance ($CaSO_4 + xMnSO_4$) is placed in a thin layer on an aluminium plate covered with mica, and the edges of the aluminium turned over. The radium is then allowed to act on this for an hour or two, after which the aluminium plate is transferred to a hot copper plate. A green disc appears at the spot above which the radium lay. G. E. A.

1648. *Induced Radio-activity Provoked by Radium Salts.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 132. pp. 548–551, March 4, 1901.)—A description of farther experiments on induced radio-activity, from which it appears that it is much more intense when the experiments are carried out in a closed vessel. Rays which are very easily absorbed are alone able to intervene, and they act on the air in immediate contact with the radiant matter. This action appears to be transmitted step by step through the air between the radiant matter and the body acted upon. (It can be transmitted through very narrow capillary tubes.) Rutherford's theory of emanation explains sufficiently well the facts observed, but other satisfactory explanations may be conceived, and it is considered premature to adopt any theory, as new facts are necessary to elucidate the question. J. J. S.

1649. *Induced Radio-activity and the Action of Radium on Gases.* **P. Curie** and **A. Debierne.** (Comptes Rendus, 132. pp. 768–770, March 25, 1901.)—It was sought to determine the part played by the intervening gas in the communication through the air of the radio-activity of a radium salt to a body rendered active in its turn. The following is a summary of the new results obtained:—

The active matter contained in an open glass tube was placed with the body to be acted upon (a sheet of copper, for example) in a sealed tube filled with air at atmospheric pressure. The body gradually becomes radioactive, and in the end attains a limited activity, always the same for the same radio-active matter. When hydrogen replaces air the same limited "activation" is observed. When the pressure of the air in the tube is varied and made somewhat low (1 cm. of mercury) the limit of activation is still the same. Consequently the quantity and the nature of the gas present have no influence on the induced radio-activity.

The result is no longer the same when, instead of a partial vacuum, a very perfect vacuum is produced in the tube ($\frac{1}{1000}$ of a millimetre of mercury), and *when this vacuum is maintained throughout the experiment* by causing the mercury pump to work continuously during the experiment. Under these conditions the body does not become active, and if it was already in an active state its activity disappears. Thus radio-activity is no longer propagated when all pressure in the apparatus is suppressed.

If after the production of a very perfect vacuum the apparatus is cut off from the pump, it is found that after an interval the sheet of copper becomes as strongly active as in air. This reappearance of radio-activity coincides with the appearance in the tube of occluded gases which raise the pressure to a slight extent. These occluded gases have been collected and their spectra examined. Carbon gases predominate, and hydrogen, nitrogen, and mercury vapour are also indicated.

The collected gases, in spite of their small mass, are strongly radio-active. They act across the glass of the tube and affect a photographic plate enveloped in black paper, and discharge very rapidly electrified bodies. Such is their activity that they also provoke fluorescence of the glass of the tube which becomes luminous in the dark. This activity of the gases steadily diminishes, but very slowly, so that gas collected and kept for ten days is still very strongly active.

The air of the laboratory in which the authors have worked for some years has become progressively more and more conducting, so that it is no longer possible to have a well-insulated apparatus, and only rough measurements can be taken with the electrometer. It is thought that this condition is not due to powders of radio-active substances which may be disseminated in the laboratory, but to the continuous formation of radio-active gases analogous to those mentioned.

The mechanism of the propagation of induced radio-activity is not yet elucidated. It may be considered that the ordinary gases contained in the air may become active from contact with radio-active matter, and then diffusing, communicate by contact their activity to other bodies; but many facts cannot be explained thus, limited activation being independent of the pressure and nature of the gas, and, moreover, the propagation of activity through capillary tubes being apparently much too rapid to be explained as due to simple diffusion of the gas. J. J. S.

1650. *Fluorescence in Diamonds.* **A. L. Foley.** (Science, 13. pp. 732–734, May 10, 1901.)—The author found that when photographic dry plates, which had been cut with a diamond on the side opposite the film, were developed, the film turned dark along the edge of the plate to the breadth of a few millimetres. The film always developed first on the side next the glass. The author traces this effect to a momentary fluorescence along the line traced by the diamond, the radiation penetrating the plate and fogging the film to a breadth

$$b = 2t . \tan i,$$

where t denotes the thickness of the glass and i is the critical angle. In every experiment, using plates of different thicknesses, it was found that b varied as t. The fluorescence depends upon the kind of glass in the plate, and also upon the particular diamond used. Some diamonds produced no effect, while another fogged the plate even when the surface of the plate was not scratched by it. With this particular diamond—an ordinary cutting diamond of medium size—the fluorescence became visible when the eye was rendered very sensitive by being kept in darkness for an hour. W. C. H.

REFERENCE.

1651. *Band Spectrum of Nitrogen.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 1040–1043, April 29, 1901.)—Tables are given of the wave-lengths of lines measured in the spectrum of air as obtained with an oscillatory electric spark [see Abstract No. 2159 (1900)]. C. P. B.

HEAT.

1652. *Manometer for verifying Boyle's Law.* **Rayleigh.** (Roy. Soc., Proc. 68. pp. 92–93, March 25, 1901 (Abstract); and Roy. Soc., Phil. Trans. 196. pp. 205–223, March 16, 1901.)—This is a description of a new form of manometer, and an account of the author's investigation of the law of the relation between volume and pressure of gases at low densities. The pressures examined are 0·01 to 1·5 mm. of mercury. The method and results of Amagat and of Bohr are stated; but the divergence from Boyle's law, recorded by Bohr in the case of oxygen, is called into question. Bohr states (Wied. Ann. vol. 27 p. 479, 1886) that at temperatures between 11°C. and 14°C., the relation between volume and pressure for pressures greater than 0·70 mm., in the case of oxygen is $(p + 0{\cdot}109)v = k$, but that for smaller pressures $(p + 0{\cdot}070)v = k$, thus indicating a change of condition of the substance. Rayleigh finds no such discontinuity.

The manometric measurement consists in adjusting the levels of two mercury surfaces with respect to two fixed points. The mercury is contained in a glass **Y**-tube, the stalk of which terminates in a flexible tube communicating with a mercury reservoir. Bulbs are blown, one in each arm of the **Y**, and each bulb has within it a fixed glass pointer, the ends of the pointers being respectively at the centres of the bulbs. The two arms of the **Y** are closed at the top; they are approximately of equal length, but one of them is bifurcated. There are thus formed three supports, whose slightly rounded ends carry a mirror platform of worked glass. The axis about which the apparatus can be turned is horizontal and parallel to the face of the mirror, so that the sine of rotation of the mirror from the zero of a fixed scale, as read by a telescope, indicates the difference of levels of the mercury surfaces when these are adjusted to the points in the bulbs. By taking into account the distance between the two fixed points, the readings can be reduced to absolute measure. In the present apparatus the distance between the points is 27·8 mm., and a difference of 1 mm. of level between the two mercury surfaces is represented by 231 mm. of the fixed scale. The greatest pressure that could be dealt with was in these experiments about 1·5 mm.

Connection with the rest of the apparatus is made by branch tubes, one from each bulb. The author finds that the requisite flexibility for this purpose can be attained by the use of a sufficient length of glass tubing between the manometer and the parts which cannot turn with it. This is specially of advantage in cases where indiarubber tubing would lead to difficulty. Full details are given of the method of using this apparatus for verifying Boyle's law, and tables are appended showing the behaviour of nitrogen, hydrogen, and oxygen. So far as the present results can settle the question, the author considers that they justify to the full the ordinary use of the McLeod gauge within the limits 1·5 and 0·01 mm. of mercury. The manometer is capable of measuring small pressures to about 0·002 mm. of mercury. R. A.

1653. *Overcooling of Floating Drops of Nitrotoluene.* **P. Bachmetjew.** (Acad. Sci. St. Pétersbourg, Mem. 10. pp. 1–63, 1900.)—Drops of *p*-nitrotoluene (m.p. 54°) were suspended, usually 10 at a time, in an aqueous solution of calcium chloride, and the time and temperature at which solidification took place were observed. The degree of overcooling of 10 groups of 10 drops, each weighing 0·0328 gramme was found to vary from 8·5° to 29·2°. The degree of overcooling reaches a maximum at a definite rate of cooling, which was found to lie between 0·60° and 0·55° per minute at 50°. When the number of drops was increased the first drop usually solidified at a higher temperature and the last drop at a lower temperature; with 100 drops, each weighing 0·00824 gramme, 21 remained liquid at 23·9° after 20 hours, and 9 were still liquid at 22·5° after 44 hours. As the size of the drops decreases the degree of overcooling under similar conditions increases, and the amount of overcooling was found to be inversely proportional to the radius of the drops when the weight of each was less than about 0·05 gm., and the radius less than about 2·4 mm. T. M. L.

1654. *Latent Heats of Evaporation of some Organic Nitrogen Compounds.* **L. Kahlenberg.** (Journ. Phys. Chem. 5. pp. 284–288, May, 1901.)—The following determinations have been made:—

	C	*p*	*t*	L	ML/T
Amyl amine	0·6136	723	95	98·75	23·3
Dipropyl amine	0·5972	745	108·25	75·69	20
Diisobutyl amine......	0·5706	735	134·5	65·85	20·8
Valeronitrile	0·5199	741	129	95·95	19·8
a-Picoline	0·4342	745	129	90·75	21

C is the mean specific heat of the liquid of molecular weight M, and L the latent heat of evaporation at temperature *t*° C. (or T absolute) under pressure *p* mm. of mercury. The last column indicates that the molecules of liquid amyl amine are somewhat polymerised, whereas those of the other substances when liquid are simple. [See Abstract No. 1498 (1901).] R. E. B.

1655. *Monatomic Gases.* **D. Berthelot.** (Soc. Franç. Phys., Bull. 167. p. 4, 1901.)—Kinetic considerations led Clausius to assign $\frac{5}{3}$ as the ratio of the isopiestic and isometric specific heats of a perfect gas, but this is found to be true only if the gas is monatomic. Similar considerations led van der Waals to give $\frac{8}{3}$ as the value of RT/pv at the critical point, but this is not true for polyatomic gases, as shown by the following values:—

Octane	3·86	Pentane.........	3·76	CO_2...............	3·61
Heptane	3·85	Benzene	3·75	N_2	3·53
Ether............	3·81	CH_4	3·67	O_2...............	3·49

But for monatomic argon $p_c = 52·8$ atm., $T_c = 155·6°$, $d_c = 0·434$ (as calculated by Mathias' formula for the ratio of the gaseous and liquid densities), so that the ratio is 2·62, which is in accordance with the theory. For polyatomic gases, therefore, van der Waals' characteristic needs modification, the co-volume doubtless depending on the number and movements of the atoms in the molecule.

Attention is drawn by **Cornu** to the asymptotic trend of the above numbers as the molecules increase in complexity. R. E. B.

1656. *Thermal and Dynamic Coefficients.* **G. H. Burrows.** (Journ. Phys. Chem. 5. pp. 233–238, April, 1901.)—The relations between Trevor's thermal, sub-thermal, dynamic, and sub-dynamic coefficients [see Abstract No. 71 (1900)], given by—

$$\begin{aligned}\theta d\eta &= \mathrm{B}_\theta dv + \mathrm{C}_v d\theta = \mathrm{C}_p d\theta + \mathrm{A}_\theta dp = \mathrm{A}_v dp + \mathrm{B}_p dv\\ -\eta d\theta &= \mathrm{E}_\eta dv + \mathrm{F}_v d\eta = \mathrm{F}_p d\eta + \mathrm{D}_\eta dp = \mathrm{D}_v dp + \mathrm{E}_p dv\\ -p dv &= \mathrm{J}_\eta d\theta + \mathrm{K}_\theta d\eta = \mathrm{K}_p d\eta + \mathrm{I}_\eta dp = \mathrm{I}_\theta dp + \mathrm{J}_p d\theta\\ v dp &= \mathrm{M}_\eta d\theta + \mathrm{N}_\theta d\eta = \mathrm{N}_v d\eta + \mathrm{L}_\eta dv = \mathrm{L}_\theta dv + \mathrm{M}_v d\theta,\end{aligned}$$

are investigated; the results (which are purely geometrical) may be written—

$$\begin{aligned}\mathrm{A}_v/\mathrm{A}_\theta &= \mathrm{E}_p/\mathrm{E}_\eta = \mathrm{J}_\eta/\mathrm{J}_p = \mathrm{N}_\theta/\mathrm{N}_v\\ \mathrm{B}_p/\mathrm{B}_\theta &= \mathrm{D}_v/\mathrm{D}_\eta = \mathrm{K}_\theta/\mathrm{K}_p = \mathrm{M}_\eta/\mathrm{M}_v\\ \mathrm{C}_p/\mathrm{C}_v &= \mathrm{F}_v/\mathrm{F}_p = \mathrm{I}_\theta/\mathrm{I}_\eta = \mathrm{L}_\eta/\mathrm{L}_\theta\end{aligned}$$

R. E. B.

1657. *Calculations of Isothermals.* **C. Dieterici.** (Ann. d. Physik, 5. 1. pp. 51–88, May 4, 1901.)—Calculations founded on Young's experimental results for isopentane lead the author to assume (1) that a gas would have a characteristic of the form $\mathrm{P} = \mathrm{R}t/(v-b)$ if its molecules exerted no action on each other; (2) that, if under these circumstances it expanded at temperature t from volume v till its pressure fell to p, the pressure actually exerted at volume v in consequence of the actual attractions between its molecules, the work done would be of the form $\mathrm{RS}/vt^{\frac{1}{3}}$, where S is a constant; (3) that the co-volume b is of the form $2\beta - \beta^2/v$, so that $\mathrm{P} = \mathrm{R}tv/(v-\beta)^2$. These assumptions give the characteristic—

$$p = \mathrm{R}t\mathrm{V}/(\mathrm{V}-\beta)^2,$$

where—

$$\log\left\{(\mathrm{V}-\beta)/(v-\beta)\right\} - \beta/(\mathrm{V}-\beta) + \beta/(v-\beta) = \mathrm{S}/vt^{\frac{4}{3}}$$

whence at the critical point $v_\kappa = 3\beta$, $t_\kappa = (4\mathrm{S}/27\beta)^{\frac{3}{4}}$.

For large values of v we might take b constant, then obtaining—

$$p(v-b) = \mathrm{R}t\, exp(-\mathrm{S}/vt^{\frac{4}{3}}).$$

[But this would give $v_\kappa = 2b$, $t_\kappa = (\mathrm{S}/4b)^{\frac{3}{4}}$.]

If v_1 and v_2 are the volumes of saturated liquid and vapour at temperature t, $\int_{v_1}^{v_2}\mathrm{P}dv$ will be equal to the latent heat of vaporisation $t(v_2-v_1)dp/dt$, whence—

$$v_1 v_2 t^{\frac{4}{3}} dp/dt = \mathrm{RS},$$

which relation is well satisfied by isopentane and benzol, and fairly by ether, $\mathrm{SO_2}$, and $\mathrm{CO_2}$, and by water at temperatures above 220° C.: the latent heat too is given by—

$$\mathrm{R}t\left[\log\left\{(v_2-\beta)/(v_1-\beta)\right\} - \beta/(v_2-\beta) + \beta/(v_1-\beta)\right],$$

an expression already found otherwise by Milner [but for the *internal* and not for the *total* latent heat, as here.] R. E. B.

1658. *Second Law of Thermodynamics.* **N. Schiller.** (Ann. d. Physik, 5. 2. pp. 313–325, May 29, 1901.)—The author bases the Second Law of Thermodynamics on the general notion of the thermal connection between bodies. Defining the thermal parameters of a body as those quantities whose changes can stand in functional relation with its temperature changes, he treats bodies as in thermal connection if the parameter changes of one body are in functional relation with those of another; the change of state of a body is adiabatic if its parameter changes occur independently of those of other bodies. From a consideration of reversible changes he derives the entropy function as a function of reversible thermal parameters of a body, which remains constant while the thermal state of the body changes in reversible adiabatic ways. He proves $dQ = \theta dS$, where Q is a quantity of heat, S the entropy function, and θ either a constant or the same function of the temperature only for all bodies, and deduces for reversible changes the relation $d\delta - dL = \theta dS$, $d\delta$ and dL being the change of internal energy and the corresponding work done by the external forces. Equations of condition are deduced from the consideration of $\theta dS + dL$ as a perfect differential. W. E. T.

1659. *Statical Theory of Radiation.* **J. D. van der Waals, Jr.** (Phys. Zeitschr. 2. pp. 461–462, May 4, 1901.)—The author seeks to explain radiation phenomena in a manner similar to that in which Boltzmann has treated the gaseous state. His method differs from Planck's in that he applies the probability law to an aggregate of radiating molecules; considering in an element of space an aggregate of molecules radiating to an external point (P), we see that the electric moments of the molecules are as probably in one direction as in the opposite, but, for radiation to reach P, deviations must occur from the most probable distribution of the moments of the molecules; these and the electromagnetic force at P vary as $\sqrt{n}$, n being the number of the molecules. This is only valid for the most probable force (f), the probability that the force lies between f and df being $ae^{-\frac{f^2}{f_1^2}}\,df$. This deduction is based on the assumption that the vibrations are independent of one another, but because of absorption a partial arrangement must exist in the molecular vibrations. The author points out the necessity of seeking for the law of this arrangement; he shows that it involves attractive forces between the molecules, and suggests the possibility of thus explaining molecular attraction. W. E. T.

1660. *Irreversible Radiation Processes.* **M. Planck.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 25. pp. 544–555, May 9, 1901.)—In his previous papers on this subject [see Abstract No. 1701 (1899)] the author gave a definition of electromagnetic entropy in an electromagnetic field in which there are resonators, and he proved that the function so defined can only increase in value until it reaches a certain maximum, and that is when the energy has the same value for each resonator, and at all points in the field. And from this he deduced the relation between radiation and temperature, showing that his results lead to a distribution of energy throughout the spectrum agreeing with that of Wien. Later researches of Beckmann, Pringsheim, and others have shown that Wien's law requires modification for all except very short wave-lengths at low temperatures. The author claims now to have found an expression for the entropy which leads to results in accordance so far with experiment, as well as with certain of Boltzmann's theorems in the Kinetic Theory of Gases. Reference is made throughout to the author's previous paper. The entropy of a resonator according to that paper was $S = -U/a\nu\,(\log U/b\nu - 1)$, where U is the energy of the resonator, ν its frequency of oscillation, and a, b are constants. He now uses the more general form $S = k\left\{(1 + U/h\nu)\log(1 + U/h\nu) - \frac{U}{h\nu}\log\frac{U}{h\nu}\right\}$, which agrees with the former for high frequencies. Here h, k are universal positive constants. The intensity of entropy radiation receives a corresponding new definition agreeing with his former one for short waves. He then proves that with this new definition the entropy increases to a maximum. Then he identifies the electromagnetic entropy with that of thermodynamics, and defines the temperature θ of a monochromatic resonator having energy U by the expression $\frac{1}{\theta}=\frac{k}{h\nu}\log\left(1+\frac{h\nu}{U}\right)$, with corresponding definition for monochromatic radiation in space. And he obtains for the whole energy of radiation per unit of volume the value, $u=48\pi\epsilon k^4\theta^4/c^3h^3$, where c is the velocity of light, and ϵ stands for the series $1+\frac{1}{2^4}+\frac{1}{3^4}+$ &c. $= 1{\cdot}0823$. An example is given of "the temperature of homocentric radiation," referring to a previous paper in Ann. Phys. 1. p. 734, 1900. [Abstract No. 1446 (1900).] S. H. B.

1661. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 37. pp. 91–99, May 3, 1901.)—In an irreversible or partially irreversible cyclic process, Clausius' inequation gives—

$$\int\frac{dQ}{T}>0.$$

It is here understood that not only T, but all the normal variables of the system, come at the end of the process to their initial values. It appeared from the author's researches that this inequation cannot be extended to permanent changes in its complete generality. This is shown by an example.

The writer had previously proposed a restricted form of the theorem, namely, that not only T and the normal variables, but also the corresponding forces, must return to their initial values. This is now shown to lead to results inconsistent with the known theory of hysteresis.

It is necessary, then, either to reject the author's modified Clausian theorem, or else still further to restrict its generality. With this view the author considers the question, in what cases Clausius' inequation can be extended to permanent changes. He concludes that Clausius' inequation is true for pseudo-reversible processes and for so-called isobaric processes, in which the forces are constant. Further, it is true for isothermal processes in which not only the system itself but also the external forces return to their initial values. But whereas he had obtained as the condition for stability that a certain function of the normal variables, namely $\phi(\alpha, \beta \ldots \lambda)$, should be a minimum. He now rejects the proof formerly given of this theorem, but holds to the theorem itself in the following form: We consider a system in which the temperature T and the normal variables $\alpha, \beta \ldots \lambda$ vary within very narrow limits. Then in order that a natural state should be stable with these variables, it is sufficient and necessary that $\phi(\beta \ldots \lambda)$ should be a minimum. [See further Abstract No. 82 (1901).] S. H. B.

REFERENCE.

1662. *Mechanical Equivalent of Heat.* **T. Barnes.** (Elektrochem. Zeitschr. 8. pp. 67–68, June, 1901. From the Oesterr. Zeitschr. für Elektrotechnik. 49. p. 590, 1900.)—A paper similar to that referred to in Abstract No. 1879 (1899). W. E. T.

SOUND.

1663. *Vibration of Air-Sheets.* **V. Hensen.** (Ann. d. Physik, 4. 1. pp. 41–59, Jan., 1901.)—In further elucidation of the manner in which a mass of vibrating gas transfers its vibrations to another mass separated from it by a gaseous sheet acting like an incompressible fluid [see Abstract No. 2196 (1900)], the author reproduces photographic records of the vibrations of sensitive flames placed in front of the lips of organ-pipes. He finds a certain degree of independence between the wave-length of a vibrating column of air and the pitch of the note. A parallel case is that of the siren, which gives the same pitch whether it is blown strongly or softly. E. E. F.

1664. *Transmission of Sound through Porous Materials.* **F. L. Tufts.** (Amer. Journ. Sci. 11. pp. 357–364, May, 1901.)—The porous materials used were cylindrical vessels filled with shot of various sizes. The coarsest material was shot 4·37 mm. in diameter, the next 2·79 mm. in diameter, and the third 1·22 mm. in diameter.

The question under consideration is, whether if two materials differ materially in the resistance offered to the transmission of sound they also differ in the same way in the resistance offered to the flow of a current of air through them.

To study the resistance offered to the flow of air through the material the shot is placed in a glass cylinder 75 cm. long, and 2·5 cm. internal diameter, closed at the bottom with a piece of wire gauze, and there connected with a gas meter, to measure the amount of air which passes through, and a manometer to register the pressure. The top of the tube is in connection with a gas-holder and another manometer, so that the difference of pressure of the gas before and after passing through the shot can be measured.

The lengths of the columns of shot were made equal to 10, 20, and 30 cm., successively, and the pressures 1, 2, and 3 cm. of water, and it was found that the time taken for a given volume of air to flow through was in each case the same; hence the resistance is directly proportional to the thickness of the material used. Experimenting with successively increasing differences of pressure, it was found that the rate of flow increased less rapidly than the pressure, and that this was more noticeable with the coarse than with the fine shot.

A series of experiments was then undertaken to ascertain if the same variation in the resistances of these substances to the transmission of sound waves existed. A thin rubber membrane was stretched on a brass ring and let into a circular opening in a piece of wood; the opening was closed above by having a cylindrical vessel placed upon the top of it, with a wire gauze bottom, in which the shot were placed. The opening was not closed below, but was exposed to the air. To the centre of the membrane was attached a rectangular piece of tin-foil, standing perpendicularly to its surface, in which a transverse slit was made, so that the amplitude of vibration of the membrane could be studied by observing the width of the slit with a microscope, a strong light being placed behind it. An organ-pipe, whose pitch could be varied, completed the apparatus. The organ-pipe, being tuned to the fundamental note of the membrane, was blown, and shot added centimetre by centimetre, the amplitude of vibration being measured at each addition; the differences of the reciprocals of the amplitudes should theoretically be proportional to the resistance offered by the various thicknesses of shot.

The results bear out the following law: That the resistance offered by granular material to the to-and-fro motion of a sound wave is proportional to the thickness of the material, other things being equal. Hence the relation between the resistance and the thickness is the same as holds for direct currents of air. W. C. O.

1665. *Rating Tuning-forks.* **J. O. Reed.** (Phys. Rev. 12. pp. 279–291, May, 1901.)—The arrangement employed is the following: A rod 8 mm. in diameter and 1 metre long is suspended by two pieces of clock spring, and at the lower end are attached a large lens-shaped piece of lead and four adjustable weights. Below the middle of the rod is clamped a ring, which carries a short arm, to which a small needle is attached so as to be parallel to the rod. Against this needle rests a fine glass tube about 0·1 mm. in diameter, attached normally to a vertical axis which carries a plane mirror. As the pendulum swings the mirror is caused to rotate about its axis through a relatively large arc. The glass tube is held against the needle by means of a drop of oil whose viscosity is sufficient to carry the mirror with it on its return swing. Light from a slit is focussed on this mirror with a lens, and thence passes through an aperture in the side of a collimating telescope placed at some distance, and, striking the base of a right-angled prism in the telescope, passes down it and out of the objective as a parallel beam. To the end of the fork to be rated is fixed a mirror; the fork is placed so that this mirror may catch the beam and reflect it once more into the telescope, where its motions can be observed by the eye. If the pendulum vibrate, the image flashes into the field of vision each time the image sweeps past the window in the telescope. When the fork is in motion, also, the image becomes a stroboscopic procession of images crossing the field. In making an observation the pendulum and fork are started and the length of the pendulum adjusted until there are between 5 and 10 flashes in the cycle. The coincidence of the flash with the cross-wire of the telescope is awaited and the flashes counted continuously, the coincidences being noted and those particularly sharp underlined. Observations are made upon the period of the pendulum at the same time. If it is not convenient to attach a mirror to the fork the flashes may be observed through a low-power microscope focussed sharply upon the prong of the fork so that it obscures about one-half the field of vision. Stroboscopic shadows are then obtained when the fork vibrates instead of the images of the slit observed in the other method. The fork may be shielded in a metal case from changes of temperature, a small hole being left for the ingress and egress of the beam of light. Numerical results are given which seem to justify the assumption that the method will give the frequency-constant to the third decimal place. A pendulum is described whose period can be altered at will while in motion by allowing mercury to leave it in a fine stream, regulated by a small stopcock with a long handle that can be turned with a touch of a pencil. W. C. O.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1666. *Duality in Electrical Theory.* **H. Sire de Vilar.** (Écl. Électr. 27. pp. 252–259, May 18, and 278–285, May 25, 1901.)—In geometry the method of reciprocal polars enables us, having given a theorem concerning points and lines, to deduce a reciprocal theorem concerning lines and points. This reciprocal relation is termed the principle of duality. The author in this paper develops reciprocal relations in electrical theory. For example, the reciprocal of the theorem that the total resistance of conductors in series is the sum of the separate resistances is that the total conductance of conductors in parallel is the sum of the separate conductances. He writes the general equation of an electric circuit in the form—

$$E_1 + E + RI = 0,$$

where E_1 is the internal counter e.m.f., E the external counter e.m.f., and RI the external ohmic drop. Dividing this equation by R, and denoting $\frac{E_1}{R}$ by I_1 and $\frac{1}{R}$ by K, we get—

$$I_1 + I + KE = 0.$$

These two equations are reciprocal theorems. The second follows from the first by writing I_1 for E_1, I for E, and K for R. The equations can also be written in the form—

$$EI + E_1I + RI^2 = 0,$$
$$EI + EI_1 + KE^2 = 0;$$

and this suggests the idea of reciprocal circuits which the author investigates for the case of shunt and series dynamos and motors. The third equation given is—

$$E_1I_1 + E_1I + EI_1 = 0,$$

which is its own reciprocal. In this paper the author discusses direct current theory only, but in a future paper he will show that the principle can be usefully applied to the theory of alternating currents. A. R.

1667. *Mechanical Representation of Electric and Magnetic Phenomena in Bodies not in Motion.* **L. Graetz.** (Ann. d. Physik, 5. 2. pp. 375–393, May 29, 1901.)—The author considers that the old dual theory of electrostatics and electromagnetics is not to be regarded as obsolete, notwithstanding the theories of Maxwell, Hertz, and their followers. The introduction of ions goes far to re-establish it. In the present paper he assumes ether to be an elastic solid capable of compression or distortion. The density ρ_1 and the abstract constant R are different for different substances. Of the second constant of electricity θ, magnetic phenomena teach us nothing. If ξ, η, ζ be the components of ether displacement, and $\sigma = \frac{d\xi}{dx} + \frac{d\eta}{dy} + \frac{d\zeta}{dz}$, then the fundamental equations for free ether are as usual—

$$\rho \frac{d^2\xi}{dt^2} = K . \left(\Delta\xi + (1 + 2\theta)\frac{d\sigma}{dx}\right), \text{ \&c.}$$

The displacement of an ether particle may be either dilatational ξ', or rotational ξ''. Every volume-element of ether is supposed to have a ponderable nucleus which resists its dilatation. On the other hand, the dilatations of ether cause relative displacements among the nuclei. The pressure p satisfies the equation—

$$p = 2K(1+\theta)\sigma,$$

whence is found for the components X, Y, Z of force—

$$X = -\frac{dp}{dx} = -2K(1+\theta)\frac{d\sigma}{dx}$$

$$Y = -2K(1+\theta)\frac{d\sigma}{dy}$$

$$Z = -2K(1+\theta)\frac{d\sigma}{dz}$$

In a conductor the decay of the displacements depends on the conductivity λ', and gives rise to the form $-4\pi\lambda'\frac{d\xi}{dt}$.

Hence the author finds the equations of motion in the form—

$$\rho\frac{d^2\xi}{dt^2} + 4\pi\lambda'\frac{d\xi}{dt} = K\left\{\frac{d}{dz}\left(\frac{d\xi}{dz} - \frac{d\zeta}{dx}\right) - \frac{d}{dy}\left(\frac{d\eta}{dx} - \frac{d\xi}{dy}\right)\right\}.$$

If L′, M′, N′ denote the components of magnetic force, we have—

$$L' = K\left(\frac{d\zeta}{dy} - \frac{d\eta}{dz}\right)$$

with corresponding equations.

The following conclusions are drawn. In a vacuum ether behaves as an elastic body, to which we can attribute the properties given by Fresnel and Neumann. In ponderable bodies action takes place between the disturbed ether and the molecules. The action of the ether on the molecules is the electrostatic force, and those parts of a substance where it continues to exist are ions. This action and reaction between molecules and intermolecular ether is expressed by Maxwell's six equations. Magnetic polarisation consists in the torsion of ether. The electric forces, other than the electrostatic, consist in the translation velocities of ether. The magnetic energy is the potential energy of the included ether. The electric energy consists of two parts—one the kinetic energy of ether, the other the potential of the mutual action of matter and ether. The so-called true magnetisation has no existence and no meaning. True electrification is the excess of the included ether above the normal. An electric current in a conductor is not an ether phenomenon, but a molecular phenomenon, consisting in the motion of molecules. The conductivity of a substance is closely related to, but not identical with, its heat conductivity and internal friction. The motions of matter and ether are not independent. The theory can easily be extended to explain the phenomena of dispersion. S. H. B.

DISCHARGE AND OSCILLATIONS.

1668. *Conductivity produced in Hydrogen and Carbonic Acid Gases by Motion of Negatively Charged Ions.* **J. S. Townsend** and **P. J. Kirkby.** (Phil. Mag. 1. pp. 630–642, June, 1901.)—Continuation of Townsend's earlier experiments [see Abstracts Nos. 2449 (1900) and 1103 (1901)], in which the conductivity produced in air at low pressures was discussed and explained by supposing negative ions to produce others by collisions with neutral molecules, these new negative ions having the same properties as those produced at the outset by Röntgen rays. This collision theory is now further discussed in the light of these new experiments in which hydrogen and CO_2 gas have been used instead of air. It is shown that the value found by Townsend for the energy required to ionise a molecule is very much smaller than that given by Rutherford and McClung [see Abstract No. 797 (1901)], whose method is criticised and considered not wholly trustworthy. Tables of results, showing the currents produced at various pressures and under varying potentials, are given, and then from theoretical considerations the formula expressing the number of ions (a) generated by a single ion under electric pressure in passing through 1 cm. of a gas whose pressure is p, is shown to be of the form—

$$\frac{a}{p}=f\left(\frac{x}{p}\right)$$

It is found that a negative ion makes 11·5 collisions per cm. in hydrogen at 1 mm. pressure, and 29 per cm. in CO_2 gas at the same pressure. Comparing these values and that for air with the collisions of molecules as given by the kinetic theory, it is seen that the mean free path of an ion is longer than that of a molecule in the following ratios :—

4·8 : 1 in H_2 ; 4·6 : 1 in CO_2 ; 4·3 : 1 in air. W. C. H.

1669. *Change of Colours of Cloudy Condensation with Number of Available Nuclei, and Effect of Electric Field.*—I. **C. Barus.** (Phil. Mag. 1. pp. 572–578, May, 1901 ; see also Phil. Mag. [5] 38. pp. 19–35, 1894.)—The nuclei are produced by passing air through a tube containing pellets of phosphorus, and the stream of air is then admitted within a cylindrical steam-jet, and the colour of the condensation produced observed. This colour depends upon the rate of admission of the charged air, and a blue colour, produced by 1 litre of air per minute, is taken as a standard. The results are given in tabular form and plotted on a curve. If the charged air is made to pass through an electric field before admission to the steam-jet, the volume of air passing per second bears a constant ratio to the electrical current passing for a constant potential-difference between the plates of the condenser producing the field ; so that, with proper graduation, the colour obtained is a measure of the current in the condenser. Using a slender tubular condenser, with distance 0·141 cm. between outer and inner electrodes, the author has found that for potential-differences of 60, 150, and 300 volts, and for all available colours, no trace of colour fluctuation in the steam-tube is to be observed, and he concludes that, unless the nuclei producing current are different from those producing condensation, the number removed by the current is insignificant as compared with the total number present. W. C. H.

1670. *Effect of a Tesla Coil on Nitrogen.* **H. Kauffmann** and **B. Hell.** (Phys. Zeitschr. 2. pp. 476–478, May 11, 1901.)—Nitrogen is allowed to stream through an apparatus very similar to an ozoniser, the inner and outer surfaces being connected to a Tesla coil. The tube is found to be filled with a bluish light, and the glass fluoresces yellowish green. When the gas stream is stopped the sparks become rose-coloured, and this colour spreads all over the tube to the exclusion of the blue and the colour of the phosphorescing glass. On restarting the flow of gas the appearances take place in the inverse order. Both blue and red lights give a line and band spectrum. Various minerals placed in the tube were found not to phosphoresce ; some, however, showed a strong thermo-luminescence when used in the form of solid solutions.

R. S. W.

1671. *Kathode Rays.* **P. Villard.** (International Physical Congress at Paris, Report, 3. pp. 115–137, 1900.)—A systematised historical *résumé* of the leading facts. The author concludes from the reducing action of kathode rays being the same whatever the nature of the gas in the tube, and whatever the kind of kathode flux, and from the relation e/m being always the same, that radiant matter is always the same; and as it is a reducer, and as the spectrum of hydrogen is always present, often alone, in the luminescent layer which marks the afflux at the kathode, he considers it probable that this radiant matter is hydrogen. A. D.

1672. *Kathode Rays and the Constitution of Matter.* **J. J. Thomson.** (International Physical Congress at Paris, Report, 3. pp. 138–151, 1900.)—The ratio e/m is much larger (about 10^7) in kathode ray corpuscles than the same ratio in electrolysis of liquids (about 10^4). The value of e is independent of the nature of the gas, and is about $6 \cdot 10^{-10}$ electrostatic units, which is of the same order as the charge of an ion of hydrogen in electrolysis. Therefore m, the mass of each corpuscle, in the case of kathode rays is about $\frac{1}{1000}$ that of the atom of hydrogen. We have therefore a new state of matter, consisting of subatomic corpuscles, invariable in mass from whatever material they be derived and in whatever manner they be produced. Each of these corpuscles carries a fixed charge of negative electricity: positive electricity seems to be always borne by ordinary matter. The positive particles in a vacuum tube present the same e/m as in ordinary electrolysis. The corpuscular condition is presented not only in kathode and Lenard rays, but also in the neighbourhood of a metal plate under ultra-violet light, in that of a filament incandescent in a very high vacuum, and in the radiations from radium and other radio-active substances. But more than this, it is, the author thinks, much more widely spread: it exists throughout metals, which seem to owe their conductivity to it, the corpuscle detached from an atom being negatively and the remainder of the atom positively charged, and fresh corpuscles being continuously formed as former ones are reabsorbed, so that the steady state is one of statistical equilibrium. The negatively charged corpuscles move easily, the positively charged remainders less so; but the corpuscles do not emerge from the mass unless their kinetic energy exceeds a limit, since work would have to be expended in separating them from the conductor. Under an electric force, the corpuscles in the metal move in an opposed direction: they thus carry a charge, and the metal appears to carry current. If they travel to a cooler part of the metal, they carry kinetic energy with them; whence thermal conductivity. If this be so, we could calculate the ratio of the thermal to the electric conductivity: the calculated ratio is fairly in accordance with facts, but the calculation is not quite conclusive in favour of this theory, and the actual ratio is not exactly the same in all metals, as it should be if the corpuscles alone carried all the electricity and all the heat. The gaseous pressure of corpuscles in bismuth works out at about ¼ atmosphere, and in copper or silver at thousands of atmospheres. Each molecule of bismuth seems to shed and reabsorb corpuscles about 40,000,000 times per second on the average: molecules of other metals much oftener than this. The collisions which determine the free path of the corpuscles seem to be those between the corpuscles and neutral atoms. If the acceleration produced by an electric force is great in comparison with the actual velocity, Ohm's law ceases to apply: in the limit the current becomes proportional to the square root of the electric force. With alternating currents in bismuth, the conductivity would disappear when the wave-length fell below 4 mm. In a

magnetic field, the corpuscles would describe arcs of a spiral instead of straight lines; with results, in the case of bismuth, showing a diamagnetic constant larger than the actual one but of the same order of magnitude and within the limits of uncertainty of the data. The impact of corpuscles upon molecules is slow in comparison with that of kathode rays; we would therefore expect not Röntgen rays but, say, calorific radiations. Corpuscles could not leak away from the metal: if one did it would leave the metal positively charged and would be attracted back: consequently there is a double film at the surface of the metal, negatively charged on the outside and positively on the inside: and for any corpuscle to get through this double film would require as much energy as would be acquired by a corpuscle passing from the high internal to the low external pressure. The energy of the corpuscles, and their tendency to quit the metal, increase with the temperature. In non-conductive compounds of the metals, the atoms of the metal already have a positive charge on account of previous loss of corpuscles. The theory explains bismuth: but for those metals in which the Hall effect and the specific heat of electricity are opposed to those of bismuth, something beyond these corpuscles is necessary; possibly positively charged corpuscles, though we have no evidence of the existence of these. The paper concludes with an investigation of the differential equations for the distribution of the corpuscles in the metal.
A. D.

1673. *Reflection of Kathode Rays.* **E. Gehrcke.** (Preuss. Akad. Wiss Berlin, Sitz. Ber. 20. pp. 461–467, April 18, 1901.)—Experiments are described showing that there is a loss of velocity upon reflection which is revealed by the greater extent to which a fluorescence-patch is displaced by a magnet. Merritt had come to a negative result. The reflected rays were retarded by a small thickness of metal, a greater thickness of which would have absorbed them. The amount of retardation depends correspondingly upon the metal of the reflector.
A. D.

1674. *Canal Rays in Rarefied Gases.* **W. Wien.** (Ann. d. Physik, 5. 2. pp. 421–435, May 29, 1901.)—A continuation of the author's work on the subject. [See Abstract No. 1287 (1900).] Many experimentalists have advanced theories of the canal rays on the supposition that they emanate from the kathode. Wien points out that they must start from the anode, for if a hole is bored through the kathode they pass through in more or less straight lines. By observation of the deflection due to a magnetic field and the heating effect on a bolometer, the ratio e/m is found, and also their velocity. A large portion of the paper is devoted to the calculation of the magnetic deflection when the field is not uniform. When the observations are made, it is found that the deflection of different parts of the stream varies from a small fraction of a mm. up to 2 centimetres, and this although great care had been taken to render the gas pure. This gives values of e/m varying from 10·1 to 36,360. The fluorescence excited on the glass is due almost entirely to the rays having the mean deflection by the magnetic field; those having a large or small deflection are almost without influence.
R. S. W.

1675. *Jaumann's J-Surface.* **A. Korn.** (Ann. d. Physik, 5. 1. pp. 136–139, May 4, 1901.)—When two electrodes are arranged at from 1 to 3 cm. apart in a vacuum tube (0·3 to 0·7 mm. pressure) and are both connected with the negative pole of an influence machine or inductorium, then if the arrangement is quite symmetrical a very bright sheet of glow is seen in the tube, midway between the electrodes. The edges of this sheet make a very bright and narrow ring of light round the bulb. If the connection of one of the electrodes is made of higher resistance, the glow shifts towards that electrode and becomes hyperboloidal instead of plane, being hollow towards that electrode. Various experimental modifications of form of this glow are described, and the conclusion is reached that Hertzian oscillations propagated in the electrodes cause radiation of negative charges, more intensely the stronger the oscillations : so that what ultra-violet rays, Röntgen rays, and Becquerel rays can do in the ordinary atmosphere, ordinary Hertzian oscillations, from sparks, can do at 0·3 to 0·7 mm. pressure. A. D.

1676. *Influence of Electric Waves on Selenium.* **A. Masini.** (N. Cimento, 1. pp. 358–359, May, 1901.)—Experiments made with all precautions against error lead to the conclusion that electromagnetic waves have no influence upon the resistance of crystallised selenium. E. E. F.

1677. *Velocity of Electric Waves along Wires.* **C. G. Barkla.** (Phil Mag. 1. pp. 652–657, June, 1901.)—A Hertzian oscillator and a Lecher's system of wires were used, the exhausted tube used by Lecher being, however, here replaced by a Rutherford's detector. By this means the wave-lengths were compared when the thickness or material of the wires in the Lecher circuit was changed. When the material was copper a change of diameter from 0·076 cm. to 0·0036 cm. reduced the wave-length about 1·8 per cent. When the wires were changed from copper of 0·015 cm. diameter to platinum of 0·0158 cm., the wave-length was reduced by about 0·37 per cent. E. H. B.

1678. *Electric Oscillation Experiment.* **H. Pellat.** (Comptes Rendus, 132. pp. 1178–1180, May 13, 1901.)—By means of a large and small condenser and a high-insulation reversing key, a spark discharge may be obtained, although the initial potential-difference was only half that required for sparking. This result, at first sight paradoxical, is explained on the theory of electrical oscillations, for it is shown that the maximum potential-difference obtainable at the terminals of the small condenser approaches three times the initial potential-difference as the ratio of the capacities of the two condensers is made to increase without limit. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1679. *Hall's Phenomenon in Mercury and Bismuth Amalgams.* **A. Amerio.** (N. Cimento, 1. pp. 342–355, May, 1901.)—Amaduzzi and Leone concluded from their experiments [Abstract No. 1850 (1900)] that bismuth amalgams showed the Hall effect, while mercury did not. The author notes that they did not observe the effect of reversing the current, and thinking that this threw some doubt on the accuracy of their conclusions he repeated their experiments.

He found that on reversing the current the galvanometer current from the cross-electrodes did not reverse, showing that the effect could not be due solely to a Hall phenomenon. The paper describes fully a number of experiments made with the view of finding the causes of this effect ; the conclusion arrived at is that what Amaduzzi and Leone attributed to Hall's phenomenon is due to a Lippmann effect, namely, to the lateral motion of the amalgam conductor, which, unless the field be exactly uniform and symmetrical, will change the equipotential lines. He verified this conclusion by introducing a bubble of air into the cell containing mercury; under the action of the field this was displaced. He concludes that bismuth amalgam does not show a Hall effect with a coefficient of 0·00004, the lowest value susceptible of measurement by his apparatus. G. H. B.

1680. *Thermo-magnetic Longitudinal Effect.* **L. Lownds.** (Ann. d. Physik, 4. 4. pp. 776-787, April, 1901. Abstract in Deutsch. Phys. Gesell., Verh. 3. 1. pp. 3-6, 1901.)—A circuit formed out of various metals placed together consists partly of bismuth. The last portion is traversed in one direction by a flow of heat, and is placed in a magnetic field whose lines of force are directed at right angles to the flow of heat. Then the e.m.f. of the circuit depends on the strength of the magnetic field. This is the thermo-magnetic longitudinal effect discovered by Ettinghausen and Nernst in 1886. The same phenomenon was observed in 1887 by Grimaldi, and described as change of the thermo-electromotive force by the magnetic field. Ettinghausen and Nernst, and later Defregger and E. van Everdingen, have accepted and supported this explanation. The object of the experiments here described was to find whether a change of the thermo-e.m.f. through the magnetic field actually takes place.

A wire of bismuth of 1 mm. diameter was taken, which, by cooling to the temperature of liquid air, showed about the same increase of specific conductivity as the wire used by Fleming and Dewar.

In these experiments the arrangement was such that a fall of temperature in the magnetic field did not take place, and then, although the magnetic field had various strengths from 4,500 to 8,100 c.g.s., it had no influence on the e.m.f. of the element. According to Kelvin's theory of thermoelectric circuits the field has, under the circumstances, no influence on the Peltier effect or Thomson effect, and thermoelectric constants of the bismuth are left unchanged.

Nernst observed that the e.m.f. p of the longitudinal effect set up by a determined field between two places, 1 and 2, depended only on the temperatures t_1 and t_2 of these places, or, according to Nernst,

$$p = (t_2 - t_1)n.$$

Thus n depends on the strength of field H, and the mean temperature $\frac{1}{2}(t_1 + t_2)$. Hitherto experiments have been conducted within very narrow limits of temperature. Lownds has determined n as a function of H between about +70° and the temperature obtainable through the use of liquid air. He gives the results in a set of curves. It is noticeable on the curve diagram (the abscissæ representing strength of field H, and the ordinates the longitudinal effect), that for a temperature of −112°, and a field-strength of 2,450 c.g.s., the longitudinal effect reaches a maximum, then decreases, and would, to all appearance, become negative with a stronger field. The effect was also observed in a plate of bismuth instead of a wire, and here at −135° the effect attains a maximum when H is about 2,000, then decreases, is negative when $H = 4{,}000$, and has an increasingly negative value as H is farther increased.

The thermomagnetic transversal effect as investigated fully by Yamaguchi is quite different; with the lowest temperature reached and the strongest fields it continues to increase. J. J. S.

1681. *Photo-electric Currents.* **M. Allegretti.** (Phys. Zeitschr. 2. pp. 317–319, Feb. 23, 1901.)—An account of observations on the e.m.f. produced by the action of light. The source of light was an electric lamp. The light could be varied in intensity, and was placed at various distances from the actinometer. Different substances sensitive to light were used, such as copper sulphide, copper iodide, silver sulphide, and silver iodide. The e.m.f. which originates through the action of light on the metallic surface dipped in an electrolyte remains, for a time which varies with each kind of actinometer, approximately constant, is then variable with a tendency to decrease, and finally completely disappears. In the first period in which the sensitiveness of the apparatus is constant, the e.m.f. called forth by the action of light on plates of sulphide and iodide of copper is inversely proportional to the distance between the source of light and the actinometer. J. J. S.

1682. *Electric Conductivity of Silver Films.* **C. Grimm.** (Ann. d. Physik, 5. 2. pp. 448–478, May 29, 1901.)—It has been found by G. Vincent that thin silver films have a higher specific resistance than silver under ordinary conditions. The author subjects this to further tests, and investigates very fully the influence exercised on the physical properties of the film by the method of silvering; a reduction of the resistance is found to take place with time. The influence of the following factors on the resistance is studied: (*a*) Temperature changes; a large decrease in resistance is found. (*b*) Effect of light; the decrease in resistance found by Lüdtke is shown to be due to the heating effect. (*c*) Passage of an electric current or of electric waves. (*d*) Polish. (*e*) Pressure; as the pressure decreases so does the resistance. (*f*) Washing with various liquids. (*g*) Influence of the surrounding gas. R. S. W.

1683. *Measurement of Large Direct Currents by a Transformer.* **H. J. Ryan.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 265–279, April, 1901.)—The method is based on the fact that the permeability of the core of a transformer is a maximum when the ampere-turns in the primary and secondary coils are equal and opposite. The large direct current to be measured is taken through the secondary, and a direct current is passed through the primary and adjusted till the permeability of the core is a maximum. The primary current is measured, and thus the secondary current is known. The permeability of the core is examined by means of two small test-coils wound on the core: one of these is supplied with alternating current taken from a two-part commutator connected with direct current mains, and the other, acting as secondary, is connected, through a commutator, with a d'Arsonval galvanometer. The deflection of the galvanometer measures the permeability of the core. A specially constructed transformer was used, with very small magnetic leakage; the main coils had 1 turn and 68 turns respectively, and the test-coils 10 turns each. In measuring a fluctuating current of 950 amperes the error was 0·4 per cent. W. H. E.

1684. *Improved Method of Applying the Insulation Overlap Test.* **W. Betts.** (Elect. Rev. 48. pp. 1048–1049, June 21, 1901.)—To obviate the delay and disturbance on the cable, and the consequent errors in localisation of the fault, by discharging, recharging, and rebalancing after each test, and striking a mean of a number of readings taken under varying conditions, the author adopts the substitution method of measurement. At a prearranged moment, the clocks being previously synchronised to a second or less, one observer takes a reading, and leaves his end of the cable insulated instead of allowing it to earth and discharge, the second observer taking a reading immediately afterwards. The two results form a distinct calculable pair, and similar pairs can be repeated as often as desirable. The charge being retained in the cable with a path of escape only through the fault tends to keep the latter constant during the tests. It is assumed that the fault would be approximately centralised by inserting resistance at the shorter end, and that due precautions with regard to the presence of earth current and reading to cable zero would be observed. E. O. W.

1685. *Localisation of High Resistance Breaks.* **J. Rymer-Jones.** (Elect. Rev. 48. pp. 959–962, June 7, and 1007–1009, June 14, 1901.)—Allowing for the cable current, if any, after making the necessary observations, the author measures the circuit resistance by direct deflections, and also the charge of the circuit. He considers the resistance, R, of the cable conductor and fault as entirely made up of cable having a mean resistance, r, per N.M. of the whole cable as laid, and the mean capacity per N.M. as obtained from the factory value. The length of this "imaginary" cable will be $\frac{R}{r}$ or L knots, and the total capacity with the distant end insulated will be Lf_1. If the distant end of the "imaginary" cable be direct to earth, and the potential at the testing end maintained the same as when the distant end was free, the static charge held by the whole length L will be $\frac{Lf_1}{2}$, equivalent to F microfarads distributed in proportion to the falling potential from a maximum at the testing end to zero at the distant end. Tables showing the distribution and sum of the static charges for each unit of this "imaginary" cable have been constructed on the supposition that it is divided into 1,000 equal parts. In reality R is only partly made up of cable conductor, the remaining resistance being in the ruptured end, which has no capacity. The fall of potential is, however, the same, and quite regular throughout the resistance R, equivalent to L knots, whether it be wholly or only partly cable conductor. By measuring therefore the static charge held by the cable portion, and calculating therefrom its capacity f, a ratio is obtained between f and the calculated total capacity F which the "imaginary" cable would have if L knots long. The values of f and F must here be understood to express only the relative capacity of the part and whole of the cable respectively, to hold a static charge under the special conditions of the test. By the aid of this ratio and his tables he is able to locate the distance of the fault from the testing end.

The distance of the break as calculated is strictly correct only when the C, R, and capacity employed for the calculation are the mean per N.M. of the ruptured portion under test. Until the approximate distance is found these will not be precisely known and a correction may be necessary. For instance, part of the cable may be in deep, cold water and part in shallow and warmer water. The author shows how the results would be corrected by the observed or estimated temperatures in this case.

The arrangements for testing are described and best modes of avoiding errors, and the form of galvanometer best suited for the purpose. E. O. W.

1686. *Schuckert's Workshop Apparatus for Measuring Hysteresis.* **J. A. Möllinger.** (Elektrotechn. Zeitschr. 22. pp. 379–381, May 2, 1901.)—In this apparatus the iron to be tested is in the form of thin sheet-iron rings, 0·5 mm. thick, having an internal diameter of 21·9 cm. and an external diameter of

32·3 cm. with five holes. Ten kilos of these rings (about 56) are weighed out and laid together with paper between them on a vulcanised fibre ring with fibre pins in three of the holes. The packet is then placed in a coil of 100 turns, the convolutions of which can be opened to admit the packet. For this purpose, each convolution is divided and the ends united by a plug engaging a socket fixed in an insulating base. The plugs are mounted friction-tight in groups of 10 in blocks of fibre so that, after they have been placed in their sockets together, they can be tightened separately by striking them with a wooden mallet. They can be removed in five groups by forcing similar series of 20 pins mounted on blocks of fibre into the sockets from the other side by means of cams. The packet is then subjected to an induction of 10,000 lines at 50 ∿ and the hysteresis loss measured by a Weston wattmeter having Swinburne and Evershed's compensating coil (see British patent, No. 3942, of 1885), arranged in series with a resistance of such value that the wattmeter only measures the watts used in the iron-testing coil. The pressure across the terminals of the coil necessary to give the standard induction above mentioned is determined once for all, and afterwards reproduced. It was found that a variation of resistance in the plug connections in the testing coil from 0·11 to 0·13 ohm, *i.e.*, 0·02 ohm variation, only caused an error of 1 per cent. C. K. F.

1687. *Astatic Galvanometer.* **M. Lippmann** and **V. Crémieu.** (Comptes Rendus, 132. pp. 1161–1163, May 13, and 1267–1270, May 28, 1901.)—An arrangement described in which a needle, in the magnetic meridian, is urged along the axis of a coil, or two coils, bearing the current to be measured: and a torsion arrangement for measuring the force. This action is not affected by the terrestrial magnetic field, and the arrangement is entirely astatic. **V. Crémieu** has followed this up by a modification which results in an extremely sensitive balance capable of serving as a galvanometer, electrodynamometer, or absolute electrometer. A. D.

ALTERNATING CURRENTS AND MAGNETISM.

1688. *Propagation of Polyphase Currents along a Number of Parallel Wires.* **W. B. Morton.** (Phil. Mag. 1. pp. 563–571, May, 1901.)—Continuing the analytical methods adopted in a previous paper [see Abstracts Nos. 516 (1901) and 1168 (1899)] the author here discusses the cases of polyphase currents of various phase-differences and along cables of different numbers of wires up to 12 wires inclusive. The effective capacity, resistance, and inductance are each dealt with, and the results obtained are exhibited both graphically and in tables. The attenuation is also worked out numerically for typical cases. It is noteworthy that the attenuation for three wires with phase-difference 120° is greater than for two wires with phase-difference 180°, that for four wires with difference 90° is equal to the two-wire value, while that for five with difference 72° is less than the two-wire value. E. H. B.

1689. *Photographic Records of Wave-shapes by means of Braun Tube.* **A. Weinhold.** (Elektrotechn. Zeitschr. 22. pp. 409–411, May 16, 1901.)—The author gives an account of the apparatus used by him for photographing wave-shapes, the oscillograph employed consisting of a Braun tube. For obtaining a displacement of the spot of light in a direction perpendicular to that of the oscillation of the kathode rays, a synchronous motor of simple construction is employed. Two such motors are described. The first consists of a series of 50 vertical iron pins, each about 3 mm. thick, projecting from the periphery of a shallow cylindrical box filled with water (so as to increase the moment of inertia of the rotor), and of a small electromagnet whose pole-pieces come to within 1 mm. of the circle of iron pins. This electromagnet is supplied with alternating current at about 18 volts. The second form of motor has a stator, whose core is made up of 40 sheet-iron stampings 0·5 mm. thick, having an external diameter of 136 mm., and an internal one of 96 mm., and furnished with four inwardly projecting pole-pieces, each about 7 mm. long. The rotor is a cross, similarly built up of 40 stampings, the arms of the cross being 18 mm. wide, and wound with a double layer of bare copper wire 1 mm. thick. The synchronous motor carries a mirror whose rotation produces the required displacement in a direction perpendicular to that of the oscillation. Reproductions of curves obtained in this way are given; the lines are somewhat coarse, and correspond to broad bands of light rather than sharply defined lines. A. H.

1690. *Stroboscopic Methods of Measuring Frequency.* **G. Benischke.** (Ann. d. Physik, 5. 2. pp. 487–488, May 29, 1901.)—The author refers to Samojloff's method [Abstract No. 117 (1901)] of determining the frequency of alternate currents, by illuminating a stroboscopic disc by a lamp fed by the current. When an arc lamp is available, the measurement can be made in daylight; with an incandescent lamp, however, if the frequency be 80 ∿ or over, the room must be darkened. To avoid this the author proposes to observe through a perforated disc, a jet of water issuing from a vessel carried by a bar of iron; the latter serves as armature to an electromagnet fed by the current, and its vibrations, when properly adjusted, cause the jet of water to break up into drops, the frequency of which is equal to that of the current. The velocity of the disc is adjusted to make the drops appear stationary. G. H. B.

1691. *Variation of Hysteresis Coefficient in Sheet-Iron.* **G. Stern.** (Elektrotechn. Zeitschr. 22. pp. 432–434, May 23, 1901.)—The experiments described in this paper were undertaken with a view of determining in how far the hysteresis loss varies over different portions of the same sheet of iron. For this purpose samples were cut and tested by means of a Ewing hysteresis tester. The results show a maximum variation of about 8·8 per cent. from the mean value, and are somewhat irregular, so that no general conclusions can be drawn from the results obtained. A. H.

1692. *Geometrical Study of a Condenser Transformer.* **E. Perreau.** (Journ. de Physique, 10. pp. 332–336, May, 1901.)—This is a geometrical investigation of the effect produced by shunting a transformer with a condenser. The author finds that in order to cause a given current to pass in a given inductive circuit we can, by placing a condenser in parallel with it, employ a less electromotive force than would otherwise be necessary, and that a smaller current will flow in the main circuit giving a diminished loss of energy.

The capacity of the condenser giving the best result is $\frac{L}{a^2}$, where L is the self-induction and a the impedance of the inductive branch. W. G. R.

1693. *Lag of Current due to Hysteresis Loss.* **F. Jacobsen.** (Elektrotechn. Zeitschr. 22. p. 529, June 27, 1901.)—If α = angle of lag of current behind p.d. in a transformer with open secondary, B = maximum induction, μ = permeability corresponding to this induction, η = hysteretic constant, then it may be shown that—

$$\sin\alpha = \frac{4\eta B^{1\cdot6}}{H.B},$$

where H = maximum magnetic intensity. Now since $\eta B^{1\cdot6} = \frac{1}{4\pi}A$, where A = area of hysteresis loop, the above formula may be written—

$$\sin\alpha = \frac{A}{\pi H.B}.$$

If now the loop be plotted so that the ordinate a, which represents B, is equal in length to the abscissa which represents H, then πH.B will in the actual diagram be represented by πa^2, *i.e.*, by the area of a circle of radius a. All that is necessary is therefore to find the area of the hysteresis loop, and to divide this by the area of the circle whose radius represents H and B; the quotient gives sin α. A. H.

1694. *Hysteresis of Nickel and Cobalt in Rotating Magnetic Field.* **R. Beattie.** (Phil. Mag. 1. pp. 642–647, June, 1901.)—The method employed by the author is to suspend a thin circular disc of the metal, with its plane horizontal, in a horizontal magnetic field. The field rotates slowly so as to avoid eddy currents and the disc experiences a couple turning it through an angle proportional to the hysteresis loss, the formula being—

$$W = \frac{\pi^2 K}{90V} \cdot \theta,$$

where W is the hysteresis loss per c.c. per cycle, V is the volume of the disc, K is the couple required to produce a twist of one radian, and θ is the deflection in degrees. Curves are plotted with intensity of magnetisation as abscissæ and hysteresis loss as ordinates. The curve for nickel shows that for an intensity of about 340 c.g.s. units the hysteresis loss reaches a maximum value of nearly 10,000 ergs per c.c. per cycle, and rapidly decreases for higher intensities. The maximum hysteresis loss for cobalt, viz., 36,000 ergs per c.c. per cycle, occurs at an intensity of 700 c.g.s. units. In both cases the last part of the curve is approximately a straight line, and if continued as such beyond the highest intensities obtained (375 c.g.s. units for nickel; 980 for cobalt) would lead to the hysteresis loss vanishing at intensities (500 c.g.s. units for Ni; 1,050 for Co) not far removed from the saturation values for the respective metals. W. C. H.

1695. *Magnetic Properties of Alloys of Iron and Aluminium.* **S. W. Richardson** and **L. Lownds.** (Phil. Mag. 1. pp. 601–624, June, 1901. Paper read before the Physical Society of London.)—This paper forms a continuation of a former one by one of the authors on the magnetic properties of an alloy of iron and aluminium [see Abstract No. 657 (1900)]. Other alloys are here experimentally examined to determine the hysteresis loss between given limits of the field strength as a function of the temperature. The alloys treated contained 3·64, 5·44, and 9·89 per cent. of aluminium. An abrupt change in the permeability of the last alloy was observed at 652° C. J. B. H.

1696. *Permeability of Nickel Steel in Strong Fields.* **R. Paillot.** (Comptes Rendus, 132. pp. 1180–1181, May 13, 1901.)—The electromagnet used was of the form due to Du Bois, and had conical pole-pieces having a semi-vertical angle of 60° 30′. Steel comprising 24·1 per cent. of nickel and 0·3 of carbon showed at a temperature of 15° C. a value of $\mu = 1·020$ in a field of 20,050, rising to $\mu = 1·083$ in a field of 30,098. Steel containing 26 to 27·2 per cent. of nickel gave $\mu = 1·19$ in a field of 4,000 c.g.s. units, this value remaining practically constant up to $H = 30,000$. The paper closes with a table of permeabilities for nickel steel with traces of chromium and manganese for fields from 3,000 to 30,000. E. H. B.

1697. *Growth of Magnetism in Iron under Alternating Magnetic Force.* **E. Wilson.** (Roy. Soc., Proc. 68. pp. 218–227, May 23, 1901.)—An iron cylinder 12 inches in diameter has exploring coils at different depths within it, wound through drilled holes crossing one another at right angles, and these coils are connected to d'Arsonval galvanometers. The cylinder was magnetised by a coil carrying a current alternated with a periodic time ranging from 2·5 to 10 minutes. Since the time-scale varies as the square of the linear dimensions of the cylinder, similar events will happen in a 1-mm. wire at 150 periods per second as were observed in the 12-inch core with a periodic time of 10 minutes. In a 1-mm. wire at 50 periods per second the average maximum B over the whole wire is 87 per cent. of that near the surface, when the latter is 2,000 per sq. cm., 80 per cent. when $B = 5,000$, and 85 per cent. when $B = 12,000$. With a periodicity of 150 these percentages are respectively 72, 65, and 65. The phase of B in different parts of the core was also examined. W. H. E.

1698. *Circular Magnetisation and Permeability.* **J. Trowbridge** and **E. P. Adams.** (Amer. Journ. Sci. 11. pp. 175–184, March, 1901.)—The permeability of an iron wire to the circular magnetisation produced in it by placing the wire in the circuit of the oscillatory discharge of a condenser is here determined. The period of oscillation is found by the revolving mirror method, the frequencies used ranging from 605 to 3,300 per second. The capacity of the condenser being known from other experiments, the inductance of the circuit is calculated from the expression $T = 2\pi\sqrt{LC}$. Finally, Rayleigh's expression for the inductance of a wire to alternating currents being used, the permeability is found. Its value was 327 for the low frequencies, 711 for the high, and 443 for the intermediate frequency of 1,280 per second. E. H. B.

1699. *Secular Displacement of the Earth's Magnetic Axis.* **A. Nippoldt.** (Phys. Zeitschr. 2. pp. 462–463, May 4, 1901.)—This article is an account of an appendix by **van Bemmelen** to the Observations of the Royal Mag. and Met. Obs. at Batavia, xxii., 1900 [published in English]. The displacement in question was calculated from the secular changes of declination at different places on the earth's surface, as shown on standard charts for different epochs. Since the magnetic meridian planes at different places do not cut in one point in either hemisphere, the end of the axis is defined as the point such that "the sum of the squares of its distances from the projections, on the tangent plane, of all meridians is minimum." The position and direction of motion of the end of the axis [which apparently is supposed to pass through the earth's centre] were computed for six epochs from 1600 to 1885, and a path was plotted. The position for 1885 was found to be about long. 68¼°, lat. 78½°. The values as calculated from different zones were different.

Thus zone 60° N.–30° N. gave $\lambda = 82^\circ$, $\phi = 80^\circ$; zone 20° N.–20° S., $\lambda = 77^\circ$, $\phi = 78^\circ$; zone 30°–60° S., $\lambda^\circ = 48$, $\phi = 74^\circ$. The path of the north end of the magnetic axis was compared with the path of the magnetic North Pole, and the distance between the two found to be about 10·5°, being nearly the same for all the epochs. The altered position of a magnetic meridian during a magnetic storm and the lull following it is regarded as due to a temporary shift of the magnetic axis while the disturbing cause lasts. "If this shift is to be regarded as a circumpolar rotation, the motion is about Nordenskiold's auroral pole, and not about the pole of the earth's rotation." Van Bemmelen's researches lead him to suspect that the position of the axis depends partly on meteorological conditions. A. E.

MEDICAL ELECTRICITY.

1700. *Physiological Action of Pole-discharges of High-tension Induction Currents and of some Invisible Radiations.* **L. Freund.** (Akad. Wiss. Wien, Sitz. Ber. 109. III. pp. 583–654, 1900.)—Direct spark discharges remove the hair from animals; they also retard the development or altogether kill the spores or cultures of *Staphylococcus pyogenes aureus*, typhus bacillus, diphtheria bacillus, anthrax bacillus, tubercle bacillus, and *Achorion Schönleinii.* The action of the direct spark discharge is increased by using an earth connection, by a longer exposure, by a smaller electrode distance, by using a more frequently interrupted primary current, and by using a stronger primary current. The action in question may take place through thin layers of wood, paper, tin-foil, aluminium, or human skin; and it affects micro-organisms suspended in liquids. The physiological action of the negative electrode is stronger than that of the positive, but is effective only at shorter distances. Silent discharges are somewhat less effective than spark discharges, but do not produce pain and are effective within greater ranges. The present investigations have failed to establish any effect of Röntgen rays on the growth of bacteria: Becquerel and phosphorescence rays give the same negative result, with no effect on the normal skin. Direct spark discharges cause hæmorrhages in the tissues of the skin, inflammations, and a pathological condition of the blood-vessels marked by the formation of vacuoles. A. D.

1701. *Electric Nerve Excitation.* **G. Weiss.** (Comptes Rendus, 132. pp. 1143–1145, May 6, 1901.)—In order that an electric excitation of a nerve may become effective, the quantity of electricity must be $a + bt$, where a and b depend on the nerve and the electrode distance. This shows that an inverse phenomenon sets in during discharge which has to be neutralised. The formula agrees with Hoorweg's. H. B.

1702. *Röntgen Rays Produced by Oudin's Resonator.* **R. Demerliac.** (Comptes Rendus, 132. pp. 1586–1587, June 24, 1901.)—In order to obviate the prejudicial effects upon Röntgen-ray patients which is sometimes observed when the vacuum tube is very near and worked by a powerful induction coil, it is here proposed to utilise Oudin's resonator, as it has been observed that tubes worked by alternate currents of high frequency and high potential exhibit effects which are curative instead of injurious. From the experiments made it is concluded that tubes designed specially for this mode of working will give as good results as the ordinary ones now in use give with powerful coils. E. H. B.

REFERENCES.

1703. *Graphic Analysis of Distorted Alternating Current Waves.* **A. S. Langsdorf.** (Phys. Rev. 12. pp. 184–190, March, 1901.)—An ingenious and simple method for determining the coefficients of the Fourier series representing the curve. The process involves only the drawing of a certain number of circles and straight lines. J. E.-M.

1704. *E.M.F. of the Clark Cell.* **H. S. Carhart.** (Electro-Chemist, 1. pp. 37–39, Feb., 1901, and Phys. Rev. 12. pp. 129–136, March, 1901.)—A summary of determinations of the e.m.f. of the Clark cell up to the present time. W. R. C.

1705. *Theory of Natural Electrification.* **M. Frank.** (Elektrochem. Zeitschr. 7. pp. 122–131, Sept.; 155–159, Oct.; 199–206, Dec., 1900; pp. 233–237, Feb.; 266–273, March; and 8. pp. 3–8, April, 1901.)—This series of articles starts with the assumption that each body possesses an appropriate negative charge whose potential depends upon temperature and other conditions of the body. Upon this hypothetical basis a number of phenomena and theories are discussed, among which are: (1) the contact potential of two metals; (2) the general theory of Volta's fundamental experiment; (3) a new thermoelectric phenomenon; (4) the behaviour of the surface layers of metals and their consequences; (5) a galvanic element which has a radio-active substance in place of the electrolyte; (6) the osmotic and thermoelectric theories of the galvanic current generation. E. H. B.

1706. *Wimshurst Machine.* **Bordier.** (Comptes Rendus, 132. pp. 761–763, March 25, 1901.)—Notes are given on the theory of the action of the Wimshurst machine without sectors. J. J. S.

1707. *Leakage of Electricity from Charged Bodies.* **J. C. Beattie.** (Phil. Mag. 1. pp. 442–454, April, 1901. Paper read before the Royal Society of Edinburgh, July, 1900.)—A second paper in continuation of that dealt with in Abstract No. 1376 (1899), and containing many additional results. E. H. B.

1708. *Period of Electric Oscillations by the Rotating Mirror.* **L. Décombe.** (Comptes Rendus, 132. pp. 1037–1040, April 29, 1901.)—A discussion of this method and the possibilities of errors to which it is open, and the means of minimising them. E. H. B.

1709. *Electrical Testing Equipment of a Cable Factory.* **W. Krejsa.** (Zeitschr. Elektrotechn., Wien, 19. pp. 236–238, May 12; 247–251, May 19; and 262–264, May 26, 1901. Paper read before the Elektrotechnishen Verein, March 20, 1901.)—This paper gives an account of apparatus suitable for the various tests usually required. W. H. E.

1710. *Dependence of Dielectric Constant and Permeability on Pressure and Temperature.* **J. Koenigsberger.** (Ann. d. Physik, 5. 1. pp. 113–120, May 4, 1901.)—A mathematical discussion, based upon the conservation of energy and Maxwell's theory, as to the simplest relations between the dielectric and magnetic constants and the pressure and temperature of the media concerned. E. H. B.

1711. *Field of Force of Electric Charges.* **T. des Coudres.** (Archives Neerlandaises, 5. pp. 652–664, 1900.)—The author discusses the various calculations which have been given by Lorentz, Heaviside, J. J. Thomson, and others with regard to the theory of the field of force of electric charges which move with a velocity comparable with that of light, and gives an investigation leading to an equation which is practically the same as that obtained by Heaviside and Lorentz. J. J. S.

1712. *Theory of Electric Conduction in Gases.* **J. Stark.** (Ann. d. Physik, 5. 1. pp. 89–112, May 4, 1901.—The substance of this paper has already been published in detached portions [see Abstracts Nos. 2202, 2203 (1900), and 98, 387, 845, and 851 (1901)]. J. B. H.

1713. *Ultra-violet Light and Actino-Electric Phenomena.* **E. Bichat** and **R. Swyngedauw.** (International Physical Congress at Paris, Report, 3. pp. 164–182, 1900.)—A historical survey as to the effect of ultra-violet light in producing (1) discharge of charged conductors, (2) charge of uncharged conductors; as to the effect of polarisation of the light used; as to the mechanism of the transport of electricity under ultra-violet light (leading up to Lenard's discovery that it is due to a spray of kathode rays); as to atmospheric electricity in this connection; and as to the effect of ultra-violet light in lengthening sparking distances. A. D.

1714. *Deformation of Condensers.* **M. Cantone** and **F. Sozzani.** (N. Cimento, 1. pp. 288–289, April, 1901.)—A correction in the values of *k* in a previous paper [Abstract No. 633 (1901)]. A. D.

1715. *Theories of Coherer Action.* **A. Turpain.** (Écl. Électr. 27. pp. 56–64, April 13, 1901.)—The author gives an account of the various theories which have been suggested to account for coherer action, and gives a classification of coherers. J. E.-M.

1716. *Theory of the Stratified Discharge.* **H. V. Gill.** (Roy. Dublin Soc., Proc. 9. pp. 415–421, June 5, 1901.)—A paper similar to that referred to in Abstract No. 1047 (1898). R. S. W.

1717. *Spark-Induction.* **Klingelfuss.** (Zeitschr. Elektrochem. 7. pp. 642–643; Discussion, pp. 643–644, May 23, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg.)—Two forms of induction coil are described—in one the iron core is straight and in the other it is a closed ring, the length of spark obtainable being 1 metre. He calculates the voltage of the discharge, which varies with the spark-gap, from known dimension of the apparatus. P. E. S.

1718. *The Electric Arc.* **Bermbach.** (Elektrotechn. Zeitschr. 22. pp. 439–442, May 23, 1901. Paper read before the Elektrotechn. Gesell. at Cologne, Jan. 30, 1901.)—A concise summary of the work which has been done by various investigators on questions connected with the electric arc. W. H. S.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1719. *Sensitiveness to Light of Fluorescein and its Substituted Derivatives and of their Leuco-bases.* **O. Gros.** (Zeitschr. Phys. Chem. 37. pp. 157–192, May 17, 1901.)—The author describes a number of experiments made on fluorescein and several of its derivatives, with the view of elucidating the changes produced in dye-stuffs when subjected to the action of light. To determine the rate of change of the various leuco-bases into the corresponding dyes, the quantity of oxygen used up is measured, two molecules of the leuco-base requiring one molecule of oxygen. The principal results arrived at are: (1) The leuco-bases of the triphenylmethane dyes are extremely sensitive to light. (2) By the entry of a nitro-group into the leuco-base of a fluorescein dye, the velocity with which it changes in the dark into the dye is greatly increased. (3) The bleaching of the triphenylmethane dyes is a process of oxidation. (4) It is very probable that the action of light concerns mainly the ions of the leuco-bases and dyes. (5) The oxidation of the leuco-base is accelerated by the formation of dye, so long as the concentration of the latter does not exceed a certain limit. (6) The sensibility to light of the leuco-bases and dyes is greatly increased by the presence of other dyes. (7) The reaction between mercuric chloride and ammonium oxalate in light is accelerated by the addition of a dye. (8) This catalytic action of the dye is shown in extremely low concentration, and, as the latter increases, the action passes through a maximum. (9) It is in the highest degree probable that the capacity of dyes to act catalytically is brought about by absorption of light. Hence the light-sensitiveness of leuco-bases extends not only to the rays which they themselves absorb, but also to those absorbed by the corresponding dyes. T. H. P.

1720. *Passivity of Iron.* **H. L. Heathcote.** (Zeitschr. Phys. Chem. 37. pp. 368–373, May 31, 1901.)—A number of experiments on the passivity of iron are described, the metal employed consisting of rods of drawn iron of 4·5 mm. diameter, and the nitric acid the ordinary "pure" acid of sp. gr. 1·408, and containing traces of nitrous acid. The criterion of passivity made use of is that no action visible to the naked eye occurs on dipping the metal into acid of sp. gr. 1·20 at a temperature of 15–17°. In all cases acid of sp. gr. 1·40 or 1·25 is capable of rendering iron passive, but only after some of the metal is dissolved. Electrolytically deposited iron (on copper) is made passive by 1·4 sp. gr. acid, but the passive condition only persists for one or two minutes in 1·2 acid. Yellow, purple, or blue annealed iron is not visibly attacked by acid of sp. gr. 1·3, but on removal is found to be passive. In concentrated nitric acid iron retains its passive state for a long time, but at the same time gradual solution of the metal takes place. Iron made passive by immersion in 1·4 nitric acid is attacked by 1·2 acid after some 20 hours' contact with it. If, however, the acid is kept in motion the speed at which the metal is rendered active is greatly increased; thus, on allowing a stream of 1·2 acid to impinge on a passive iron rod immersed in acid of the same strength, the metal becomes active after one minute. Exactly the opposite is, however, the case when stronger acid (sp. gr. 1·275) is made use of. In other liquids (unmoved) the passive state persists for very different

periods: in concentrated potassium nitrate solution, a few seconds; in double-normal potassium hydroxide, 2–3 minutes; and in saturated solutions of potassium bichromate or ferric alum, several days. Iron can also retain its passive condition when not in contact with any liquid, as is shown by completely removing the acid from a piece of passive iron and placing the latter in a vessel which can be evacuated. In about 50 per cent. of the samples examined in this way the passivity is found to persist after 93 hours, the pressure being 7–8 mm. of mercury. Several of these results are directly contradictory to the views of Hittorf [see Abstract No. 2283 (1900)].
T. H. P.

1721. *Gypsum and Anhydrite.* **J. H. van't Hoff, W. Hinrichsen,** and **F. Weigert.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 25. pp. 570–578, May 9, 1901.)—It having been previously shown that gypsum ($CaSO_4$, $2H_2O$) changes at 107° into the half-hydrate ($CaSO_4$, $\frac{1}{2}H_2O$), the authors describe further experiments to determine the temperature at which further loss of water occurs, with the formation of anhydrite. Contrary to expectation, it is found that the transformation of the half-hydrate into anhydrite takes place at a temperature lower than 107°. In accord with this result is the observation that the tension of water-vapour of a mixture of gypsum and anhydrite is greater than that of gypsum and half-hydrate. From these facts it follows that the half-hydrate can of itself change into gypsum and anhydrite, and is hence unstable or meta-stable. Evidence of this is found in the absence of a layer of half-hydrate intermediate between those of gypsum and anhydrite in natural salt deposits. Further confirmation of this is obtained by experiment.
T. H. P.

1722. *Flame Spectra of the Basic Bessemer and Open-hearth Processes.* **W. N. Hartley** and **H. Ramage.** (Roy. Soc., Phil. Trans. 196. pp. 479–506, June 5, 1901; and Abstract in Roy. Soc., Proc. 68. pp. 93–97, March 25, 1901.)—Photographs of the flame, sparks, and fume at the various stages of the "blow" were taken, as well as of the spectra, and differed entirely from the results in the "acid" Bessemer process as recorded in former papers. The continuous spectrum was much stronger, and many new lines and bands were observed. Rb, Cs, Ca, Cu, Ag, and Ga were identified, besides K, Na, Li, Fe, and Mn. Very careful analyses of the materials and products were also made, and gallium oxide was separated from the iron. No information was furnished by the spectroscope as to phosphorus, probably because that element is fixed by Ca and Fe and not volatilised, but an insight was obtained into the chemistry of the process, and as to the wide distribution of rarer elements and the variations of spectra with temperature. The open-hearth and cupola flames did not show the lines, because the atmosphere is an oxidising one. The basic Bessemer "blow" is vividly described, and the spectra tabulated. It is shown that Rb and Cs accompany the lime, while Ga, Cu, Ag, and some Rb enter with the iron. A new line of potassium with variable intensity was established, λ 4642–3. V and Ti are removed with the slag along with the phosphorus, and do not appear in the spectrum. By analysis Pb, Cr, Ni and traces of Co were found in the basic steel, and Sr in the lime, but their lines were not visible in the converter flame. Certain variations of the spectra caused by temperature are described.
S. R.

1723. *Density of Alloys.* **E. van Aubel.** (Comptes Rendus, 132. pp. 1266–1267, May 28, 1901.)—The alloy AlSb melts at 1078°–1080°, while Al melts at

660° and Sb at 638°. It is found that its sp. gr. is 4·2176 instead of 5·2246 assuming no expansion (Al 18·87 at sp. gr. 2·67 and Sb 81·13 at sp. gr. 6·72): there is therefore a considerable increase in volume, contrary to Matthiessen's rule. A. D.

1724. *Results of Chilling Copper-Tin Alloys.* **C. T. Heycock** and **F. H. Neville.** (Roy. Soc., Proc. 68. pp. 171–178, May 23, 1901.)—Attempts to elucidate the nature and composition of copper-tin alloys were made by the microscopical examination of their structure. The paper is illustrated by photographs of the structures observed in the slowly cooled as well as in the chilled or suddenly cooled alloys. It is considered "that the patterns of slowly cooled copper-tin alloys are, at all events until they have been confirmed by the examination of chilled portions, entirely misleading as to the separations that occurred during solidfication. Even the evidence for the existence of the compound Cu_3Sn will have to be revised." N. L.

1725. *Thermo-chemistry of Alloys of Copper and Zinc.* **T. J. Baker.** (Roy. Soc., Phil. Trans. 196. pp. 529–546, June 13, 1901. Abstract in Roy. Soc., Proc. 68. pp. 9–10, March 5, 1901.)—A number of experiments on the same lines as those previously described [Abstract No. 1112 (1900)] were made, the heat of formation of the different alloys being calculated from the heats of solution of the alloy and of the two constituents. The solvents employed were chlorine water, ammonium ferric chloride solution, and ammonium cupric chloride solution. The production of an alloy of copper and zinc is always attended by evolution of heat, the maximum evolution of 52·5 calories per gramme corresponding with the alloy $CuZn_2$; the heat of formation of this compound would therefore be 10,134 calories per gramme-molecule. There is also evidence of the existence of an alloy CuZn, having a heat of formation of about 45 calories per gramme. These results are in agreement with Kelvin's calculation of the molecular dimensions of copper and zinc as lying between 10^{-8} and 10^{-9} cm. It is also pointed out that a complete theory of the electro-deposition of brass must take into account the energy liberated in the combination of copper with zinc. N. L.

1726. *Studies on Inversion.* **E. Cohen.** (Zeitschr. Phys. Chem. 37. pp. 69–83, May 3, 1901. Paper read before the Akad. Wiss. zu Amsterdam, May 25, 1900.)—It has been shown by previous observers that the hydrolysis of ethyl acetate by alkalis is retarded by various substances, such as glycerol and sugar, usually classed as non-electrolytes. In the present paper are described series of experiments on the influence of sucrose, invert sugar, dextrose, lævulose, and mannitol on the velocity of hydrolysis of N/40 ethyl acetate by N/40 sodium hydroxide at 25°. The results, which are given in tables, and also in the form of curves, show that mannitol exerts but little influence on the reaction, whereas the sugars exercise a comparatively strong retarding influence, and may therefore be regarded as weak acids. N. L.

1727. *Velocity of Chemical Reactions.* **W. Duane.** (Amer. Journ. Sci. 11. pp. 349–356, May, 1901.)—Two methods are described for measuring the rate of change, the first, applicable to transparent bodies, depending on alteration in the index of refraction, the instance given being the inversion of cane sugar. By the apparatus illustrated it is proved that "the distance of the image at any time from its final position after the reaction has been completed is very approximately proportional to the amount of cane sugar left in the solution at the time." The image of a slit is photographed successively on the same plate, and the distances measured by a micrometer scale. It appears that the velocity of the reaction is greater at the beginning and less at the end than would be expected from Gouldberg and Waage's law that the rate at which the cane sugar disappears should be proportional to the amount left in solution.

The second method is based upon the change in the volume of the chemical system during the reaction. The liquids are contained in a spiral glass coil with a ground stopper and cup at one end, and at the other a capillary tube with a mercury index, the whole being enclosed in a bath regulated to a constant temperature by an electrical thermostat devised by the author, sensitive to $\frac{1}{1000}$ degree. In the apparatus described, the spiral tube contained 100 c.c. of solution, the capillary was 36 cm. long, and 1 sq. mm. in section, and the temperature was 25·872° C. The velocity of change was again less rapid at the end. A third method depending on the change in the index of refraction as measured by the motion of inteference bands is under investigation. S. R.

1728. *Order of Crystallisation of Minerals in Igneous Rocks.* **J. A. Cunningham.** (Roy. Dublin Soc., Proc. 9. pp. 383–414, May 7, 1901.)—The order of crystallisation of minerals in igneous rocks can generally be expressed by Rosenbusch's law that the most basic rocks crystallise first, and, in particular, quartz is always the last to crystallise in deep-seated plutonic rocks. This order is, however, entirely different from the order of the melting-points and Joly has therefore suggested that the order of crystallisation is dependent on the temperature at which the minerals become viscous or ductile. A considerable amount of evidence is available to show that whilst a fibre of amorphous silica becomes ductile at 800°, quartz itself does not melt until above 1,400°, and as quartz is denser than amorphous silica this melting-point would be raised by increasing the pressure. Bunsen, in 1850, showed that in the case of paraffin wax and spermaceti the melting-point of the more fusible paraffin rises more rapidly than that of spermaceti on increasing the pressure, so that above 95 atmospheres the order of fusibility is reversed; if the melting-points of augite or orthoclase rise more rapidly with increase of pressure than the melting-point of quartz, they should separate the first under great pressures, but the last under low pressures, and evidence is given to show that this change in the order of crystallisation actually occurs in certain granite masses at different depths.

The paper gives an account of the methods by which the influence of pressure on the melting-points of minerals may be determined, but the data are at present very scanty. T. M. L.

1729. *Theory of Colloidal Solution.* **F. G. Donnan.** (Phil. Mag. 1. pp. 647–652, June, 1901. Paper read before the Physical Society of London.)—The author shows that the phenomena of colloidal solutions can be explained by means of Laplace's theory of intermolecular attractive forces. The pseudo-solution of colloidal matter is regarded as a process of molar or mechanical disintegration due to the non-existence of statical equilibrium in the thin surface-layers of the solid when the latter is in contact with certain liquid media. Any small volume-element in the bounding interface of a solid immersed in a liquid is acted on by two forces, one l due to the attraction of the solid, and the other r to that of the liquid. For crystalline solids l is greater than r, while for colloidal matter in contact with certain liquids it is assumed that r is greater than l. The solid will therefore begin to disintegrate into the liquid ; and to account for the stoppage of the disintegration process before the molecular limit is arrived at, that is, before true solution sets in, the author further assumes that the molecular adhesion between the liquid and solid is greater than the molecular cohesion of the colloid and that for the latter, the intermolecular attractive forces fall off more rapidly with increasing distance than for the former. Hence there exists a critical thickness of the colloidal substance such that the forces l and r just balance and when this state of division is reached the process of disintegration ceases, the result being a two-phase system consisting of the colloidal medium distributed in a state of extremely fine division throughout the liquid.

T. H. P.

1730. *Solubility of Mixtures.* **V. Rothmund** and **N. T. Wilsmore.** (Zeitschr. Elektrochem. 7. pp. 676–677 ; Discussion, pp. 677–678, May 30, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—By extending Dalton's law to dilute solutions it should follow that the solubility of a substance would not be influenced by the addition of small quantities of a third substance. This is not the case where electrolytes are concerned, and the solubility of a non-electrolyte in water is always diminished by the presence of an electrolyte ; for example, the solubility of a non-electrolyte in a normal solution of a sulphate is 40 per cent. less than its solubility in water. From this it must follow that the solubility of the electrolyte in water is diminished by the presence of the non-electrolyte, and the equation—

$$l_1 \log_e \frac{L_1}{l_1} = i l_2 \log_e \frac{L_2}{l_2}$$

is deduced, where L_1 and l_1 are the solubilities of the non-electrolyte in water and in a saturated solution of the electrolyte, L_2 and l_2 are the solubilities of the electrolyte in water and in a saturated solution of the non-electrolyte, and i is van't Hoff's factor. To test this formula an experiment was made with water, phenol, and potassium sulphate where—

$$L_1 = 0{\cdot}893, \quad l_1 = 0{\cdot}493, \quad i = 2{\cdot}33,$$
$$L_2 = 0{\cdot}671, \quad l_2 = 0{\cdot}534 :$$

these figures give—

$$l_1 \log_{10} \frac{L_1}{l_1} = 0{\cdot}127, \quad i l_2 \log_{10} = \frac{L_2}{l_2} 0{\cdot}121,$$

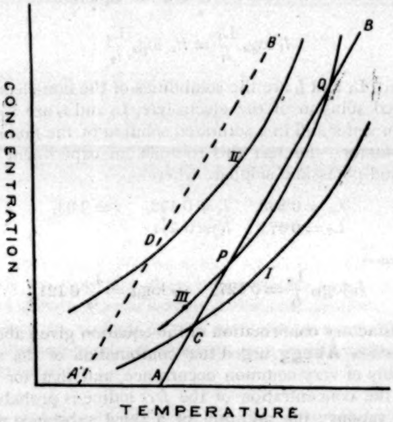
and afford a satisfactory confirmation of the equation given above.

In the discussion **Abegg** urged that combination of the solute with the solvent is probably of very common occurrence, and that, for instance, in an iodine solution the concentration of the *free* iodine is probably only that of saturated iodine vapour ; the addition of a third substance would decrease the active mass of the solvent and so diminish the amount of combined iodine and reduce the solubility.

T. M. L.

1731. *Solubility of Gases in Organic Solvents.* **G. Just.** (Zeitschr. Phys. Chem. 37. pp. 323–367, May 31, 1901.)—Results are given of the measurement of the solubilities of carbon dioxide in 44 organic liquids and of carbon monoxide, nitrogen, and hydrogen, in 17 liquids, besides a few mixtures of such liquids, the modified form of Ostwald's apparatus devised by Timofejew and Steiner being employed. The numbers obtained for carbon dioxide show that for the series of the monohydric alcohols the solubility of the gas decreases as the molecular weight of the alcohol increases, and the same relation holds for the fatty acids, the aromatic hydrocarbons, and the alkyl acetates. Similar relations are not met with in the cases of the other gases examined. The solubility values at 20° and 25° show that, between these temperatures the solubilities of nitrogen, hydrogen, and carbon monoxide in most liquids increase as the temperature rises, whilst the opposite holds in the case of carbon dioxide. From a table giving for the different gases at 25° the liquids arranged in the order of their dissolving power, it is seen that the series for nitrogen and carbon monoxide are almost identical. Further, while for other pairs of gases the ratios of the solubilities in one and the same liquid vary considerably for the different solvents, the solubility of carbon monoxide is in all cases about 1·44 times (at 25°) that of nitrogen in the same liquid. Whether these relations depend in any way on the equal molecular weights of the two gases concerned is unknown. Numerous tables of experimental numbers accompany the paper. T. H. P.

1732. *Separation of Salts by Evaporation of Dilute Solutions.* **F. W. Skirrow** and **H. T. Calvert.** (Zeitschr. Phys. Chem. 37. pp. 217–219, May 17, 1901.)—If the line AB represents the boiling-points of solutions of different concentrations the solubility curve will usually intersect it at a single point; and on evaporating a dilute solution, solid will separate at a temperature and concentration represented by the point C (curve I). In other cases the solubility curve (II) does not intersect the boiling-point curve, and the temperature can be raised to the melting-point of the salt without any separation of solid taking place; this case is illustrated by aqueous solutions of sodium and potassium hydroxides; if the evaporation takes place under reduced pressure the line AB will be moved to a parallel position A′B′ nearer the origin, and solid may then separate at a temperature and concentration represented by the point D. In certain cases the solubility curve (III) may intersect the boiling-point curve at two points, P and Q, and solid will then separate only at intermediate temperatures. T. M. L.



1733. *Experimental Verification of a Law of Chemical Dynamics.* **H. Pélabon** (Comptes Rendus, 132. pp. 1411–1413, June 10, 1901.)—The law $p_1 p_2 / p_3 p_4 = f(t)$ is here tested for the reciprocal reaction given by—

$$HgS + H_2 = H_2S + Hg,$$

by experimenting (1) with H_2 acting on HgS alone, (2) with H_2 acting on HgS with Hg present in excess, (3) with H_2S acting on Hg in excess. In (1) the calculated value of the ratio of the partial pressure of H_2S to the whole pressure is always slightly larger than that obtained by experiment; in (2) calculation and experiment are in good agreement; in (3) the agreement is less good, doubtless owing to partial decomposition of H_2S during the sealing of the tubes. [See also Abstract No. 1121 (1900).] R. E. B.

1734. *Fundamental Equations of Multiple Points.* **J. E. Trevor.** (Journ. Phys. Chem. 5. pp. 259–260, April, 1901.)—A deduction is given of the equations due to Saurel [See Abstract No. 1354 (1901)], and it is pointed out that the fundamental equation may also be written in the form—

$$\overline{W}_{12} \frac{dp_{12}}{d\theta} + \overline{W}_{23} \frac{dp_{23}}{d\theta} + \ldots + \overline{W}_{(n+2)1} \frac{dp_{(n+2)1}}{d\theta} = 0,$$

W_{mn} being the work absorbed in the transfer of unit mass from the *m*th to the *n*th phase.

The author also deduces, in the case of a one-component system, the equations—

$$\overline{Q}_{12} \frac{d\mu_{12}}{dp} + \overline{Q}_{23} \frac{d\mu_{23}}{dp} + \overline{Q}_{31} \frac{d\mu_{31}}{dp} = 0,$$

$$\overline{W}_{12} \frac{d\mu_{12}}{d\theta} + \overline{W}_{23} \frac{d\mu_{23}}{d\theta} + \overline{W}_{31} \frac{d\mu_{31}}{d\theta} = 0,$$

μ being the chemical potential: these equations admit of extension to *n*-component systems. W. E. T.

1735. *Thermodynamics of Saturated Solutions.* **N. Schiller.** (Ann. d. Physik, 5. 2. pp. 326–348, May 29, 1901.)—This is a mathematical paper in which the author treats of the behaviour of saturated solutions under varying external conditions; for example, he inquires whether these variations cause some of the undissolved substance to dissolve or some of the dissolved substance to precipitate. Among other things he proves that, in the case of a single substance in solution, external pressure in general promotes solution and the osmotic pressure in a saturated solution is in general increased by compression. In cases where two fluids dissolve into one another and form two saturated solutions the effect of the external pressure in general depends on the relative quantities of the two fluids. The osmotic pressures of both solutions, certain particular cases being excepted, are increased by increase of external pressure. W. E. T.

1736. *Salt Formation between Cane Sugar and Potassium Hydroxide as shown by Conductivity.* **C. J. Martin** and **O. Masson.** (Chem. Soc., Journ. 79. and 80. pp. 707–714, June, 1901.)—It is found that the conductivities of solutions of KCl and HCl are decreased by the addition of cane sugar. This effect, which is due to the increase of viscosity and has been investigated by Arrhenius, is found to follow very approximately a linear law, $l = l_0(1 - ax)$, where l = conductivity of solution, l_0 = conductivity of solution containing no sugar, x = grm.-mols. sugar per litre and a = a constant.

In the case of KOH, however, the results are quite different, showing with increase of sugar concentration a much more rapid rate of falling off in conductivity at first. As the solution gets stronger with respect to sugar the rate of decrease of conductivity diminishes, the result being a markedly curved line when l is plotted against x. These results point to the formation of "sucrate" ions in the solutions, and show that in the presence of a strong base cane sugar can act like a weak acid. [Compare the results of Kullgren, Bihang t. Vet. Akad. Stockholm 24, II., No. 8, 1898.] F. G. D.

1737. *Vapour-Pressures of Isomorphous Mixtures of Salt-Hydrates.* **R. Hollmann.** (Zeitschr. Phys. Chem. 37. pp. 193–213, May 17, 1901.)—It is found that isomorphous mixtures possess true maximum vapour-pressures independent of the amount of water of crystallisation present, between certain limits, and that the vapour-pressure of a salt-hydrate is always lowered by isomorphous admixture, provided the latter be small.

On varying the proportions of the two salts present it is found that the vapour-pressure curves exhibit cusps, which must be regarded as the points of intersection of different curves. These cusps occur always at points corresponding to simple ratios of the component salts, and in fact indicate the existence of corresponding *double-salts* formed by the isomorphous constituents. The following double-salts appear on these grounds to exist:—

2 mol. iron alum + 1 mol. ordinary alum.
2 mol. chrome alum + 1 mol. ordinary alum.
2 mol. magnesium sulphate + 1 mol. zinc sulphate.
1 mol. " " + 1 mol. " "

F. G. D.

1738. *Influence of Sodium Sulphate on the Vapour-Pressure of Aqueous Ammonia.* **E. P. Perman.** (Chem. Soc., Journ. 79. and 80. pp. 725–729, June, 1901.)—The author gives the values of the vapour pressure of ammonia solutions containing sodium sulphate for temperatures varying from 26° to 47°. Comparison with the numbers for pure ammonia solutions shows that the vapour pressure is much increased by the presence of sodium sulphate, and is even higher than it would be on the supposition that the hydrate $Na_2SO_4.10H_2O$ is formed, the concentration of the ammonia being thus increased. This effect is probably due to a displacement, more physical than chemical, of the ammonia by the salt. The vapour-pressure curves of ammonia solution containing dissolved sodium sulphate are continuous, indicating that no sudden change occurs in the state of hydration of the salt. This observation agrees with the now generally-accepted view that the break in the solubility curve of sodium sulphate at 33° is due to a change in the solid with which the solution is in contact. T. H. P.

1739. *Vapour-Pressure of Aqueous Ammonia Solution.* Part I. **E. P. Perman.** (Chem. Soc., Journ. 79. and 80. pp. 718–725, June, 1901.)—Results are given of measurements by a statical method of the vapour-pressures of aqueous ammonia solutions of concentrations varying from 0 to 35 per cent. for temperatures of 0° to 60°. No simple relation can be observed between the vapour-pressure and the concentration, or between the vapour-pressure and temperature of the solution. Curves and tables accompany the paper.

T. H. P.

1740. *Cryoscopic Experiments with the Bromides of Arsenic and Antimony.* **F. Garelli** and **V. Bassani.** (Accad. Lincei, Atti, 10. pp. 255–262, April 14, 1901.)—The authors give the results of cryoscopic measurements of benzene, bromoform, iodine, arsenic tri-iodide and trichloride, stannic iodide, antimony chloride, and bromide in arsenic bromide solution and of diphenyl, diphenyl-methane, bromoform, antimony chloride, arsenic tri-iodide, and tribromide in antimony bromide. The numbers obtained lead to the following conclusions. The mean molecular freezing-point depression for arsenic bromide is 194·2, which agrees well with the value given by Raoult's empirical rule, namely, 195·3. Solutions of antimony chloride in arsenic bromide give freezing-point depressions much less than the theoretical, a fact ascribed by the authors to the formation of solid solutions. Tolloczko [see Abstract No. 883 (1900)] found that solutions of arsenic bromide in antimony chloride give small depressions of the freezing point, and he supposed that either dissociation or a chemical action such as $AsBr_3 + SbCl_3 = AsBr_2Cl + SbCl_2Br$ takes place. This explanation is untenable in the light of the authors' observations. The small depressions obtained by Tolloczko for solutions of arsenic bromide in antimony choride are probably also due to the analogy in constitution existing between the solvent and solute. Anomalous values are also obtained for mixtures of the bromides of arsenic and antimony, and are evidently due to the formation of isomorphous mixtures. Tolloczko (*loc. cit.*) corrects the number, 280, previously given by Garelli for the molecular freezing-point depression of stannic bromide, giving the value 306. The authors point out that both from the results of Tolloczko and those of Garelli the latter number is too high, whilst 280 agrees well with the value given by Raoult's rule, the melting point and latent heat of fusion leading to the number 260. T. H. P.

1741. *Conductivity of Solutions of Salts in Liquid Sulphur Dioxide up to and above the Critical Temperature.* **A. Hagenbach.** (Ann. d. Physik, 5. 2. pp. 276–312, May 20, 1901.)—The conductivity of solutions of a number of iodides and bromides when dissolved in sulphur dioxide was determined at temperatures up to and above the critical point (156° C.). When the critical point was reached it was noticed that with coloured solutions the vapour began to be coloured just before the disappearance of the meniscus, but that after the meniscus had disappeared the vapour in the lower part of the tube was much more deeply coloured than that in the upper part of the tube; similarly the lower layer of vapour had a much higher conductivity than the upper layer. This is due to the slowness with which the solute diffuses; the inequality disappears gradually if the temperature is kept constant, or immediately if the tube is shaken.

Electrolytic conductivity, accompanied by polarisation, was observed at temperatures a few degrees *below* the critical point both in the saturated and the unsaturated vapour, and also in the vapour *above* the critical temperature. The temperature-coefficients of the liquid solutions were negative, and amounted to about 2 per cent. per 1° for temperatures between 100° and 140°; potassium iodide, however, showed a positive temperature-coefficient between 18° and 87°, the conductivity rising to a maximum at the latter temperature. Just below the critical temperature a large decrease of conductivity occurs, the temperature-coefficient increasing in magnitude to about —50 per cent. Above the critical temperature the temperature-coefficient of the vapour is again small. The conductivity curves are therefore continuous from the liquid to the gaseous state, but show a marked inflexion just below the critical temperature.

Corresponding experiments with water as a solvent were impracticable owing to the dissolution of the glass, but a maximum of conductivity was once observed at 310° in a solution of potassium chloride containing a large amount of dissolved glass. [See also Abstract No. 2456 (1900)]. T. M. L.

1742. *Calculation of the Ionisation of Strong Electrolytes.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 37. pp. 315–322, May 31, 1901.)—The values of i determined by the freezing-point measurements of Loomis and Hausrath for KCl, NaCl, and HCl are compared with the values calculated from the formula $i = 1 + \alpha$, where α is ascertained from the conductivity. It is maintained that the agreement is as good as could be expected in consideration of the experimental errors. According to the author [Abstract No. 908 (1901)] Jahn's measurements appear to indicate a constant error of about 1 per cent. The author points out, however, that he does not identify i with $1 + (n - 1)\alpha$ in *all* cases, as that would be tantamount to assuming the validity of the simple gas laws in all cases. The formula given by the author for the e.m.f. of a concentration cell does *not* assume the gas-laws, and is exact. Nevertheless in many cases of dilute solutions of binary electrolytes the equation $i = 1 + \alpha$ holds, as shown above. F. G. D.

1743. *Free Formation-energy of Water, and a New Electrode Sensitive to Light.* **E. Bose.** (Zeitschr. Elektrochem. 7. pp. 672–675, May 30, 1901. Paper read before the Deutsch. Elektrochem. Gesell. at Freiburg.)—Various observations recently made indicate that the value of 1·08 volt for the e.m.f. corresponding to the reversible formation of water from hydrogen and oxygen is certainly too small. The author gives various values founded on the experiments of different observers. As a provisional value for this e.m.f. at 76 cm. pressure and 25° C. temp. the number $E = 1{\cdot}1392 \pm 0{\cdot}0150$ volt is given. In considering the effect of the electrode metals, the author experimented with an element with gold electrodes of a special construction. He found this cell sensitive to light and various diagrams are given showing the changes of e.m.f. when the electrode was exposed to light of different colours and when the light was not allowed to reach it. J. J. S.

1744. *Acetylene as a Depolarising Agent.* **A. Coehn.** (Zeitschr. Elektrochem. 7. pp. 681–684, June 6, 1901. Paper read before the Deutsche Elektrochem. Gesellschaft at Freiburg, April 19, 1901.)—Using acetylene at the anode in an alkaline solution (KOH) formic acid is produced in quantitative proportions, and the discharge potential of the anion is lowered by 0·48 volt. The current-efficiency of the cell worked in this way lies between 95·9 and 98·7 per cent., and corresponds to the equation—

$$C_2H_2 + 6OH = 2HCOOH + 2H_2O.$$

Substituting normal sulphuric acid as electrolyte, the lowering of the discharge potential of the anion only equalled 0·19 volt, and chemical tests proved that acetic acid was formed with the corresponding aldehyde as an intermediate product.

The formation of acetic acid at the anode was proved to be quantitative.

Further experiments with the halogen acids as electrolytes yielded inconclusive results, but a slight lowering of the discharge potential of the anion was noted. The investigation is being continued by the author.

J. B. C. K.

1745. *Periodic Phenomena in Electrolysis.* **K. Kœlichen.** (Zeitschr. Elektrochem. 7. pp. 629–633; Discussion, pp. 633–635, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—Periodic phenomena occur in the electrolysis of sodium and ammonium sulphides, similar to those observed by Ostwald in the dissolution of metallic chromium [Abstract No. 163 (1901)]. The p.d. at the kathode remains steady whilst that at the anode varies widely; the polarisation at each electrode remains steady and the fluctuations in the current are therefore due to a variable anode resistance. This variation of resistance has been traced to the deposition of sulphur and subsequent dissolution in the sulphide. The period is much shorter than that observed by Ostwald. The variations of current were recorded by means of a hot wire connected to the pen of a recording apparatus. The phenomenon is most marked in strong solutions of sodium sulphide with a current-density of 10–20 amperes per sq. dm. and rough platinum electrodes. The presence of polysulphides in the solution makes the phenomenon less pronounced, but this effect can be partially overcome by increasing the concentration and current-density. For each concentration there is a minimum and a maximum temperature at which the variations can be observed, the necessary current-density being small at the minimum temperature and large at the maximum. Similar periodic phenomena occur in the electrolysis of potassium iodide, and two other cases are mentioned in the discussion. T. M. L.

1746. *Electrolytic Phenomena at the Junction between two Solvents.* **E. H. Riesenfeld.** (Zeitschr. Elektrochem. 7. pp. 645–647, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—An investigation of the concentration-changes produced by the current at the interface between solutions of the same electrolyte in two partially miscible solvents. It is shown theoretically that there will be an increase of concentration at one junction, and an equal decrease at the other (supposing the two solutions to be contained in a U-tube), and that this variation of concentration will be proportional to the difference between the migration-constants of the kation (or anion) in the two solvents. Experiments are described with KI, distributed between water and phenol. If Ficks' law of diffusion be employed, and a linear distribution-law between the two solvents assumed, it is found possible to obtain expression free from the integral sign, giving the state of the solution at any given point and any given time. Thus if m_1 and m_2 denote the fluxes *from* the interface *into* the solvents 1 and 2 respectively, it appears that m_1 and m_2 are independent of the time, and that—

$$\frac{m_1}{m_2} = k \sqrt{\frac{D_1}{D_2}}$$

where the D's denote diffusion-coefficients, and k is the distribution-coefficient. It is shown how the migration-constants for the KI in the phenol solution can be determined from analyses of the aqueous kathodic solution alone; in this way the mean value (0·81) is found for the migration constant of the kation. F. G. D.

1747. *Electrolytic Reduction of Ketones.* **K. Elbs.** (Zeitschr. Elektrochem. 7. p. 644, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—As a general rule the reduction of ketones by sodium hydrate and zinc dust yields the corresponding alcohols, while reductions by zinc dust and glacial acetic acid yield the pinacones. Complex ketones, containing aromatic radicle groups, are not, however, in all cases reduced by chemical means, and, therefore, experiments were made to test the effects of electrolytic action. The best results were obtained when using slightly acid or alkaline solutions with lead electrodes. Under such conditions all ketone derivatives could be reduced by electrolysis. This method of reduction has, in fact, been found to work so well that the firm of E. Merck has patented its application to the production of isopropylalcohol and pinacone from acetone. A 90 per cent. yield has been obtained for this reduction in the laboratory trials of the process. J. B. C. K.

1748. *Electrolytic Separation of Cobalt and Nickel.* **D. Balachowsky.** (Comptes Rendus, 132. pp. 1492–1495, June 17, 1901.)—An acetic acid solution of the two metals is employed, with the addition, for each 0·3 gramme of metal, of 3 grammes of ammonium sulphocyanide, 1 gramme of urea, and 1 or 2 c.c. of ammonia to neutralise the excess of acetic acid. The liquid should measure about 100 c.c., and is electrolysed at 70–80° in a Classen capsule, using an e.m.f. not exceeding 1 volt and a current density at least $ND_{100} = 0{\cdot}8$ ampere; 1½ hours is required for the electrolysis. Under these conditions the nickel is deposited on the kathode in the form of sulphide, which is subsequently dissolved in nitric acid, and the metal is deposited by Classen's usual process. N. L.

1749. *Electrolytic Chromium.* **B. Neumann.** (Zeitschr. Elektrochem. 7. pp. 656–658; Discussion, pp. 658–661, May 30, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—After referring to Bunsen's experiments in 1850 for the deposition of chromium from its solutions, the author gives his own experience on the subject. His investigations were made by means of simple solutions of chromium salts contained in the kathodic compartment, the anode compartment containing mineral acids or solutions of a salt. The kathode consisted generally of carbon; however, such metals as platinum, brass, lead, &c., may be employed, and the anode may be, according to the solutions, of lead, platinum, or carbon. Vigorous agitation of the solutions is essential, as otherwise the solutions round the kathode will rapidly become exhausted, owing to the great current-densities which must be employed, and only oxides of chromium will be the result.

Tables referring to concentration, temperature, and current-densities employed are given; yields ranging from 5·4 per cent. to 89·5 per cent. of the theoretical were obtained. Sulphate solutions were also tried and yielded up to 84·6 per cent., with 65–85 grs. of chromium per litre. Acetate solutions gave poor yields and bad deposits. If properly prepared, the deposits have a tendency to peel off in thin layers, somewhat like nickel. Thicker deposits of several millimetres may, however, be made, and are very pure, only containing 0·1 to 0·2 per cent. of iron. Both modifications, *i.e.*, the active and passive, were obtained, as in Goldschmidt's method. A discussion followed the paper. O. J. S.

1750. *Electrolytic Preparation of Benzidine.* **W. Löb.** (Zeitschr. Elektrochem. 7. pp. 597–603, May 9, 1901.)—Under certain conditions, azoxybenzene may be reduced to benzidine with a yield of 64 to 70 per cent. Azoxybenzene (2 grammes) is suspended in 25·75 per cent. hydrochloric acid (70 c.c.), containing stannous chloride (1–1·5 grammes) in solution; the liquid is placed in a porous pot standing in hydrochloric acid. The kathode is formed of pure nickel gauze, and it is also used as a stirrer in order to keep the azoxybenzene in suspension. The kathodic current-density may vary from 0·008 to 0·05 ampere per sq. cm., and the temperature from 60° to 90°. Little or no benzidine was obtained when other salts were added to the solution, or other metals used as kathodes. O. J. S.

1751. *Electrolytic Bleaching.* **W. McA. Johnson.** (Elect. World and Engineer, 37. p. 765, May 11, 1901.)—A brief illustrated article, giving details of experiments carried out in the Laboratory of Trinity College, Hartford, Conn. The fabric to be bleached was saturated with a solution of sodium chloride containing free hydrochloric acid, and placed between two carbon electrodes carrying a weak current at an e.m.f. of 2 volts. The bleaching effect at the anode is due to the nascent oxygen, produced by the secondary chemical reaction between the liberated chlorine and the water. The best results are obtained with a very small current-intensity, and an e.m.f. below 1·67 volts, as that is the "Zersetzungspunkt" of the OH ions. J. B. C. K.

1752. *Bell Type of Alkali Cell.* **G. Adolph.** (Zeitschr. Elektrochem. 7. pp. 581–589, May 2, 1901.)—The principle of this type of cell is that gravity effects the separation of the alkali hydrate-solution formed at the kathode. The anode compartment is simply the suspended bell jar, and no diaphragm is used to separate the anode and kathode compartments of the cell. The best results were obtained when using platinum as anode material, the current-efficiency under favourable conditions rising to 97·68 per cent., but eminently satisfactory efficiencies were obtained with carbon anodes, 92·97 per cent. and 92·68 per cent. being recorded in two separate experiments. The possibility of working continuously with this form of alkali cell was shown by a test lasting seven days, during the last five of which fresh salt solution was continuously fed into the cell. The current-efficiency obtained during this trial was 82·1 per cent.

The author concludes his paper by stating his belief that this type of cell is worthy of attention by those interested in the technical aspects of the subject. J. B. C. K.

1753. *Electric Production of Ferro-Silicon.* **G. Gin.** (Ind. Élect. 10. pp. 173–178, April 25, 1901; also Écl. Électr. 27. pp. 177–185, May 4, 1901.)—The first portion of this paper deals with the part that silicon plays in the Bessemer process. The following is the order of oxidation in this process: Silicon, manganese, iron, carbon, and finally phosphorus, the latter being fixed by means of basic materials such as lime, &c. Thermo-chemical data are then considered, and the importance of the heat supplied by means of the combustion of the silicon explained, 7,830 calories being thus disengaged. One per cent. of silicon in cast iron, low in carbon, imparts to it the maximum tensile strength. Certain classes of open hearth and Bessemer steels are also improved by the presence of silicon if properly balanced with the percentage of carbon present. The various silicides of iron, five in number (Fe_3Si, Fe_2Si, Fe_3Si_2, Fe_2Si_2, and $FeSi_2$) with 14·28 per cent. to 50 per cent. of silicon are then fully described. The industrial production of ferro-silicon at Meran is explained. Charges similar in composition to those in blast furnaces were first employed, the only difference being the reduction of coke on account of the heat supplied by the current. The mixture consisted of 1,000 kilos iron oxide, 410 kilos sand, and 398 kilos coke, 70 watts being employed per sq. metre, the operation lasting fifteen hours with a yield of 776 kilogrammes, which equals 1,240 kilogrammes for twenty-four hours per furnace, or 80 per cent., calculated on the silicon employed, the final product containing 21·45 per cent. Si. Cost of production per ton, 200 francs. Ferro-silicons of a higher percentage were also produced, and up to 83 per cent. yield obtained. The sale price in Austria is 200 kroners for a 10 per cent. alloy, the price being correspondingly higher with an increase of silicon. In France, ferro-silicon of 10 per cent. is worth about 180 francs, and a 25 per cent. alloy 300 francs. This is an increase of 8 francs for each per cent. between 10–25 per cent. Above 25 per cent. each unit costs 10–12 francs per ton. At another works, trials with inferior silicious ores were made containing manganese, the latter being nearly entirely volatilised. The results in this case were very satisfactory, 75 per cent. of the electrical energy employed being accounted for. The most satisfactory results were, however, obtained by employing practically worthless acid and Siemens-Martin slags as raw material, yielding ferro-silicon and silico-spiegels containing about 30 per cent. silicon. The loss of silicon in this case was somewhat higher, owing to the high temperatures employed. Power consumed per ton equalled 5,380 kw.-hours. A saving of 12 per cent. of power was thus effected, and 120 kilos less coke employed, thus saving 14 francs per ton without counting the further saving on account of valueless raw material. Reference is also made to Scheid's method of the production of metallic silicon, and the author states that he has obtained much better results by using a mixture of silicon, carbon, and fluorspar. The whole paper is carefully worked out from thermo-chemical data. O. J. S.

1754. *Reduction of Arsenic Ores in the Electric Furnace.* **C. Hering.** (Elect. World and Engineer, 37. pp. 670–672, April 27, 1901.)—The author points out that arsenic ores are not mined much in the U.S.A., in spite of the high gold values often contained therein, because the arsenic interferes so materially with the smelting operations. In some cases, as in Butte Mont, the arsenic from copper ores escapes up the chimney in the form of white arsenic, which is most harmful to the country around. The new method of electrical reduction, of which the author has made a quantitative test, enables the arsenic to be removed from the ore in the form of metal, leaving the other metallic constituents of the ore in the shape of a matte.

The process is applicable to mispickel or arseno-pyritic ores which contain arsenic in the form of sulpho-arsenide of iron, *i.e.*, according to the formula $FeS_2 + FeAs_2$. The ore when dressed contains 46 per cent. of arsenic. In accordance with the theory, by heating this ore in a closed furnace without access of oxygen, the iron combines with the sulphur, forming the easily fusible ferrous sulphide FeS, while the arsenic distils off as a metallic vapour, which condenses into a fine metallic powder. The gold and silver and other metals remain behind as a matte, in which the original percentage of these metals is 80 or 90 per cent. higher owing to the removal of all the arsenic. The process consists in passing an alternating current through a horizontal column of the ore, which conducts sufficiently to allow a heavy current to pass, whereby it is fused. When fused the ore conducts well. The arsenic is removed by a current of nitrogen, which passes through two sets of condensers, one before and one after the furnace, and circulates thus continuously without loss. A reversing valve enables the direction of the current of nitrogen to be changed, whereby a saving of heat is effected by pre-heating the nitrogen in the already hot condenser, on the well-known principle of the regenerative furnace. The arsenic powder is removed from the condensers through traps. A tap is provided for drawing off the fused matte.

In the small furnace used for the experiment, 185 lbs. of ore was fed in per hour, the current varying from 4,000 to 8,400 amperes, and the voltage from 22 to 12. This is at the rate of 1,140 kilowatt-hours per ton of 2,000 lbs. As, however, the furnace was a small one, and much heat was lost through radiation, this is capable of considerable improvement.

The inventor is G. M. Westman, of New York, who is about to apply the process to some mispickel ore containing on an average 5·75 dollars in gold. As there is water power available near the mine, a great saving in the cost of transport is anticipated.

The author finally discusses the best methods of introducing large alternating currents into such a furnace, without heavy losses due to induction. J. L. F. V.

1755. *Electrolytic Perchlorates.* **F. Winteler.** (Zeitschr. Elektrochem. 7. pp. 635–642, May 23, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—The author's experiments related to the influence of concentration, current-density, temperature, and electrode material upon the efficiency of the cell process when electrolysing chlorate solutions. As regards the effect of concentration, the efficiency remained in all cases about 70 per cent. until the amount of undecomposed chloride present in the solution had fallen to 8 per cent. when a rapid decline occurred.

The experiments with variable current-density and temperature showed that, at all temperatures, increased current-density produced increased efficiency, while increased temperature produced the inverse effect, namely, a diminished efficiency.

As regards electrode material, polished platinum yielded the best results

The remainder of the paper is taken up with a discussion of the various methods of working a chlorate cell, those of Gall and Montlaur, Oettel, and Müller being referred to. The author used all three methods in an attempt to obtain perchlorates by the direct electrolysis of chloride solutions. His experiments upon this point showed that, whether using diaphragms (Gall and Montlaur's method) or working without diaphragms, no perchlorates were formed so long as 5 per cent. of undecomposed chloride remained in the cell. The formation of chlorate was therefore a necessary intermediate step in the process. J. B. C. K.

REFERENCES.

1756. *Binary Systems: A Theorem of le Chatelier.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 277–280, May, 1901.)—This is a demonstration, by the use of a formula given by van der Waals, of the relation recently established by le Chatelier between the slopes of the concentration curves of two bivariant binary systems under constant pressure at their point of intersection. R. E. B.

1757. *Relations between Atomic Weight, Atomic Volume, and Melting-Point.* **T. Bayley.** (Chem. News, 83. pp. 243–245, May 24, 1901.)—Tables are given exhibiting a connection between the atomic volume and the absolute melting-point of various pairs of elements and the "critical points" considered by the author to indicate the commencement of the various cycles, or, on the hypothesis of atomic condensation from cooling protyle, the temperatures at which the tide of evolution underwent periodic change. T. H. P

1758. *Theorem of Roozeboom.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 281–283, May, 1901.)—This theorem—that, if in a bivariant binary system consisting of a liquid solution and a solid solution the addition of a small quantity of one of the components to the liquid phase lowers the temperature of solidification, then the concentration of that component is greater in the liquid phase than in the solid phase—is shown to be an immediate consequence of a formula given by van der Waals. Further, the protasis of the theorem may be thus stated—if the addition of a small mass of one of the components to the solid phase lowers the melting-point of that phase. R. E. B.

1759. *Relation between Osmotic Pressure and Work.* **C. Dieterici.** (Zeitschr. Phys. Chem. 37. pp. 220–222, May 17, 1901.)—A reply to Noyes [Abstract No. 675 (1901)], objecting to his new definition of osmotic pressure as giving something that is no *truer* and that is far less easily calculable than that defined by van't Hoff. R. E. B.

1760. *Change of Weight in Chemical and Physical Reactions.* **A. Heydweiller.** (Ann. d. Physik, 5. 2. pp. 394–420, May 29, 1901.)—This paper contains a detailed account of experiments already described in preliminary note [see Abstract No. 2267 (1900)]. T. H. P.

1761. *Liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 5. 1. pp. 236–239, May 4, 1901.)—The author replies to the arguments of Tammann [Abstract No. 1352 (1901)] in favour of the view that the so-called liquid crystals consist in reality of emulsions of one liquid phase in another. T. H. P.

1762. *Electrodeposition of Alloys.* **R. A. Lehfeldt.** (Electro-Chemist, 1. pp. 137–139, June, 1901.)—A short account of the principles underlying the electrodeposition of alloys and the difficulties still requiring elucidation ; the researches of J. Walter and Cowper-Coles are referred to. N. L.

1763. *Electrolytic Regeneration of Chromic Acid Solutions and Manufacture of Diaphragms.* **M. le Blanc.** (Zeitschr. Elektrochem. 7. pp. 653–656, May 30, 1901. Paper read before the Deutsche Elektrochem. Gesell. at Freiburg.)—Supplement to the paper referred to in Abstract No. 540 (1901). Account of the working of diaphragms made of an improved mixture. A. D

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1764. *Angular Displacement of Prime Movers.* **L. Fleischmann.** (Elect. World and Engineer, 37. pp. 920–921, June 1, 1901.)—When alternators are to be run in parallel, it is necessary to specify accurately the permissible maximum angular displacement of the prime movers. An accurate graphical method of doing this from the velocity diagram of a steam engine is given in this paper. Let θ be the actual angle described by a radius of the flywheel in time t, and let ϕ be the angle it would have described had it been moving with the mean angular velocity $\frac{2\pi}{\mathrm{T}}$, where T is the period of a revolution of the flywheel; then if ω be its instantaneous angular velocity—

$$\omega = \frac{d\theta}{dt}; \quad \frac{2\pi}{\mathrm{T}} = \frac{d\phi}{dt}$$

$$\therefore \omega - \frac{2\pi}{\mathrm{T}} = \frac{d(\theta - \phi)}{dt}$$

Hence $\theta - \phi$ is a maximum or a minimum when the angular velocity of the flywheel equals $\frac{2\pi}{\mathrm{T}}$, its mean angular velocity.

Again— $$\theta - \phi = \theta - \frac{2\pi}{\mathrm{T}} \int_0^{\phi} \frac{1}{\omega}\, d\theta \text{ ....}(1)$$

Now measure a length OA equal to $\frac{\mathrm{T}}{2\pi}$ along OY and a length OB equal to 2π along OX. Through A draw AP parallel and equal to OB. On OB as base construct, from the velocity diagram of the steam engine, a curve having $\frac{1}{\omega}$ and θ for its ordinates and abscissæ respectively, the time being chosen so that this curve passes through A and P. Then this curve will have an equal number of loops above and below AP. If M be the area of a loop whose base is AT, then $\theta - \phi$ is a maximum or a minimum at the point T, and its value is $2\pi \frac{\mathrm{M}}{\mathrm{T}}$. A. R.

1765. *Steam Engines for Electrical Purposes.* **J. S. Raworth.** (Inst. Elect. Engin., Journ. 30. pp. 971–978, June, 1901. Paper read before the Manchester Section of the I.E.E., March 12, 1901.)—The author points out that while dynamo design tends towards uniformity, there still remains a great diversity of opinion with regard to engines. In England the three-crank high-speed vertical engine is the leading type, while in America slow-speed engines, and on the Continent one-crank engines seem to take the lead. The three-crank engine (*i.e.*, the engine having a compound or triple expansion engine on each crank), has advantages in the matter of vibration; it is, however, not so economical of steam, due to greater leakage length of piston ring, greater area of cylinder-walls, and the difficulty of applying automatic expansion. Its turning moment is nearly constant, but with single or two-crank engines running at more than 200 r.p.m., no practical difficulties arise in respect of turning moment. At Wandsworth there are three 300-h.p. engines with single cranks driving Mordey alternators in parallel at 213 r.p.m. without any trouble. At Bournemouth two-crank engines with the cranks at right angles were once used, but the running in parallel was unsatisfactory. This was remedied by putting the cranks opposite one another. A triple-expansion engine very rarely has any great advantage over a compound engine for electrical work, and with superheated steam the best results are said by Schmidt to be obtained from compound engines. The author thinks that the three-crank three-cylinder compound engine is likely to be much used in the future for large units of from 2,000 to 5,000 h.p., similar to those built by Musgrave for the Glasgow tramways. The l.p. cylinders of such an engine are only slightly larger than the h.p. cylinders, the engine can be easily balanced, has a fairly even turning moment at all loads, and automatic expansion can be applied without difficulty. An engine constructed on these lines, but working at a high speed, would have many advantages. W. H. S.

1766. *Experiments on a Niclausse Water-tube Boiler.* (Engineer, 91. pp. 339-340, April 5, 1901. Summarised by **Bryan Donkin** from a paper read at the Congrès de Mécanique, Paris.)—In each of these trials made by M. Niclausse, lasting about eight hours each, nine rates of combustion with the same coal were employed from a minimum of 10 lbs. to a maximum of 60 lbs. per square foot of grate per hour. The steam was evaporated in all at atmospheric pressure from a feed-water temperature of 11° C. or 52° F. Both coal and water were carefully weighed. The following were the rates of combustion employed on the trials, viz., 10, 15, 20, 25, 30, 35, 40, 50, and 60 lbs. of coal per square foot of grate surface per hour. At all these rates the percentage of water evaporated from each separate row of tubes in terms of the total evaporation from the 12 rows, remained the same. The boiler was composed of 12 rows of steel tubes, 10 in each row. External diameter of tubes, 3·23 ins., or 82 mm.; length of each tube, 6·35 feet, or 1·94 m. External surface of each row, 5 square metres or 53·8 square feet; total heating surface, 5 × 12 = 60 square metres, or 53·8 × 12 = 645 square feet. Grate area, 2 square metres or 21·5 square feet. Ratio of total heating to grate surface, 30 to 1. The internal circulating tubes were each 40 mm. or $1\frac{9}{16}$ in. diameter. The calorimetric value of the coal used was 12·91 lbs. of water from and at 212° F. per lb. of coal. Neither the temperature nor the composition of the escaping gases was examined; the tests were merely as to the relative evaporation from each

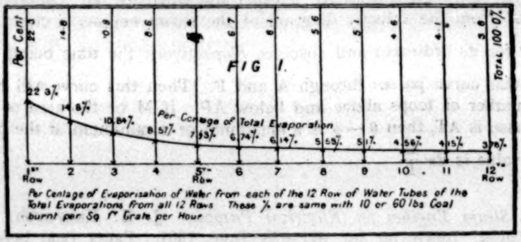


FIG 1.

Per Centage of Evaporisation of Water from each of the 12 Row of Water Tubes of the Total Evaporations from all 12 Rows These % are same with 10 or 60 lbs Coal burnt per Sq Ft Grate per Hour row of tubes. The plotted results are shown in four diagrams. Fig. 1 (which is here reproduced), gives the plotted results of evaporation from each row in percentage of the total evaporation. The first three rows nearest the fire, with 161 square feet of heating surface, gave nearly 50 per cent. (47·94) of the total evaporation from 645 square feet, the remaining 50 per cent. (52·06) requiring three times the surface.

Fig. 2 gives the evaporative rates from each row of tubes, in lbs. of water per square foot of heating surface per hour, for the nine different rates of combustion. The first row nearest the fire evaporated from a minimum of 8¼ lbs. to a maximum of 34⅓ lbs., whilst the twelfth row evaporated only from 1½ to 6 lbs. per square foot per hour.

Fig. 3 shows the heat-efficiency for each row of tubes at the different rates of evaporation. The lowest rates of combustion yield the highest heat-efficiencies.

Fig. 4 gives the plotted results on a base line of lbs. of water evaporated per square foot of heating surface per hour, with boiler efficiencies as a vertical scale. The curves represent the results obtained from the different rows at the different rates of combustion, and show that the higher rates of combustion and greater evaporation per square foot give less boiler efficiency.

F. J. R.

1767. *Efficiency of Marine Boilers.* **G. M. Brown.** (Mech. Eng. 7. pp. 628-631, May 4, 1901. Abstract of a paper read before the North-east Coast Institution of Engineers and Shipbuilders.)—This paper is a review of the practice during the last twenty years with marine boilers of the cylindrical type with fire tubes, and directs attention to the following points: (1) The waste of heat in producing chimney draught. (2) The use of superheaters. (3) The use of feed-heaters. (4) The advantage of air-heaters. (5) Some devices for increasing heat-absorbing surface. (6) The effects of closing some of the tubes and the advantage of using small tubes. (7) The combination of air-heater and steam superheater in some steamers.

(1) Assuming 700° F. to exist at the base of a funnel 65 feet high, and the atmosphere to be at 62° F., then $w = 0{\cdot}0146\,\mathrm{H} - \frac{7{\cdot}66}{\mathrm{T} + 461} = 0{\cdot}52$ inch of water, where w = draught in inches of water; H = height of funnel in feet, and T = temperature of the gases. The draught w is distributed as follows:—

	Inch.
Resistance due to the funnel, uptakes, and smokebox............	0·02
" " tubes	0·11
" " firebox, bridge, furnace	0·06
" " fire of moderate thickness	0·31
" " inertia of column of gases	0·02
Total........................	0·52

With coal yielding 14,700 B.Th.U. per lb., and 19 lbs. of air used for combustion per lb., giving 20 lbs. of gases, having an average specific heat of 0.23, then—

$$20 \times 0{\cdot}23\,(700 - 62) = 2{,}934{\cdot}8 \text{ B.Th.U.}$$

(or about 20 per cent. of the heat generated), is used for draught production. To work fans for a consumption of about 30 lbs. of coal per square foot of grate per hour, about 3 per cent. only are required according to Bertin, or 1·3 per cent. according to John Brown & Co., for their triple-expansion fan engines.

(2) Superheaters were fairly successful with lower steam pressures. At present there is not so much margin for economy. In the ss. *Inchkeith* the boiler pressure is 260 lbs. per square inch, the temperature of the steam at inlet to superheater is about 400° F., the temperature of the waste gases at the smokebox is about 650° F., and above the superheater about 450° F.; with natural draught, the latter temperature would have to be higher.

(3) Reference is made to E. Kemp's feed-heaters and their results (see Trans. Inst. of Engineers and Shipbuilders in Scotland, vol. 32, p. 201), and to the revival of the use of feed-heaters with water-tube boilers.

(4) Howden's, and Ellis and Eaves' plans for heating the air for combustion are referred to.

(5) and (6) The result of C. Wye Williams's experiments with conductor pins (see "The Combustion of Coal," &c. London, 1858, pp. 214–223), and results of experiments with "Serve" tubes and spiral retarders are referred to. The fact that the lower rows of tubes have a much more sluggish draught than the upper rows is made the basis for a form of retarder which reduces the inlet area of the tubes in a diminishing ratio from the top rows to the bottom. Such retarders have been proposed by Hawke, then by West, and latterly by Scott, the latter being described and illustrated.

Isherwood's experiments as to the effect of varying the relation of heating to grate surface by plugging up tubes or inserting ferrules, are quoted; and results of the use of Scott's retarders as compared with spiral retarders and no retarders in the same boiler are given, the average showing 9·7 per cent. saving in coal and 1 per cent. in time in favour of Scott's as against the use of no retarders.

(7) Lastly, the introduction of combined air-heaters and steam superheaters in the ss. *Inchkeith*, *Inchmarlo*, and other steamers is mentioned with some results—the *Inchkeith* having on a trip from Hartlepool to Dover consumed only 0·97 lb. of coal per i.h.p. hour. Further saving is predicted by the addition of feed-heaters to this arrangement.

F. J. R.

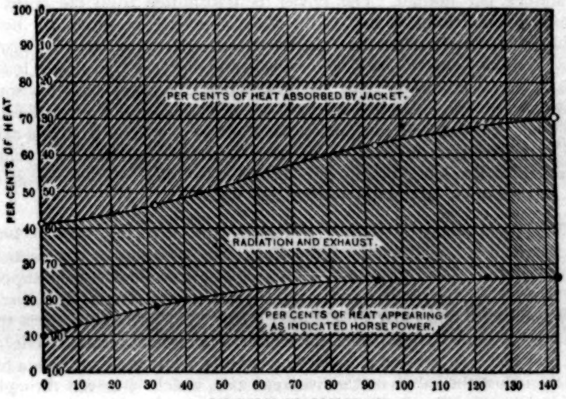
GAS AND OIL ENGINES.

1768. *Test of Westinghouse Gas Engine.* (Eng. Record, 43. pp. 527–528, June 1, 1901. Abstract of a paper read before the American Society of Mechanical Engineers, Milwaukee, by **C. H. Robertson.**)—In previous tests [see Abstract No. 898 (1900)] the engine was not in very good condition; better results are here given of another series of tests upon the same engine after it had been thoroughly overhauled. During a six-hour run, using natural gas to air in the proportion of 1 to 13·7 parts by volume, the average i.h.p. was 113, the highest 142 and the lowest 52. The corresponding b.h.p. was 92, 123, and 31. The frictional loss in engine varied from 15 to 31 h.p., the average being 21. The lowest consumption of natural gas per i.h.p.-hour was 9·7 cubic feet, and per b.h.p.-hour was 11·29 cubic feet. The best thermal efficiency was 157 British thermal units per i.h.p. per minute; and nearly one-quarter of the energy of the gas was realised as work at the flywheel.

Short brake tests, each of 45 minutes, were made to find the distribution of heat between indicated h.p., the water-jacket, and the exhaust ; the following results were obtained with the various loads:—

Duration of test in minutes	40	45	45	45	45
Revolutions per minute	265·5	263·3	261·3	258·3	256·9
Indicated h.p.	18·57	48·48	116·0	143·8	164·2
Brake h.p.	0	31·4	93·6	123·4	143·2
Frictional loss h.p.	18·57	17·08	22·4	20·4	21·0
Standard gas used per i.h.p.-hour in cubic feet	25·8	14·34	10·32	9·87	10·14
Percentage of Heat—					
Converted into indicated work	10·2	18·3	25·4	26·6	25·9
Absorbed by water-jacket	57·6	53·6	37·0	32·1	29·6
Loss in exhaust and radiation	32·2	28·1	37·6	41·3	44·5

Thus with no load on the brake, the percentages of heat in these three



HEAT BALANCE
OF WESTINGHOUSE GAS ENGINE. *FIG. 1.*

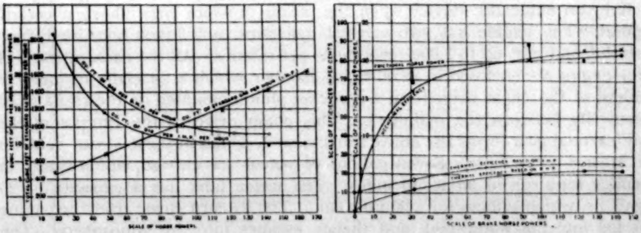


DIAGRAM OF GAS USED.

EFFICIENCIES AT DIFFERENT LOADS.

FIG 2

factors were 10, 58, and 32 respectively. At full load, *i.e.*, 143 b.h.p. or 164 i.h.p., the per cents. were 26, 30 and 44. The chart (Fig. 1) illustrates the fact that a decrease in loss by water-jacket produces an increase in exhaust loss. The loss by engine friction, average 19·9 h.p., is practically constant, so that the mechanical efficiency increases to 87 per cent. as the load increases. The curves in Fig. 2 show the relation between the horse-power and efficiency of the Westinghouse gas engine. W. R.

AUTOMOBILISM.[1]

1769. *Cottereau Gasoline Vehicle.* (Horseless Age, 8. pp. 154–156, May 15, 1901. From La France Automobile.)—This vehicle has a rectangular underframe of steel tubing carrying a 5½ h.p. motor in front, a change-speed gear of the Panhard type, but with fixed bevel drive, and a single chain gear to the exterior of the differential on the live rear axle. The engine has two cylinders, each at an angle of 21° from the vertical. The bodies of the cylinders are air cooled with deep radiating ribs, and the heads are water cooled. The cylinders are bolted to an oil-tight crank chamber, the cylinder dimensions are 3¼-inch bore by 4-inch stroke, and the normal speed is 1,000 revolutions per minute. The power is transmitted from the crank shaft through a cone-friction clutch, to the change-speed gear, which, by means of sliding spur wheels, gives three forward and one reverse speed. From the upper shaft carrying the fixed spur wheels, the power is transmitted to a cross shaft by means of a bevel gear. At one end of the cross shaft is a sprocket pinion geared by a chain to a sprocket wheel on the exterior of the differential gear box. The underframe and carriage body is sprung from the axles by long plate springs. Steering is on the Ackerman system. The vehicle is controlled by two hand brakes, one on the cross shaft of the change-speed gear and the other on the differential gear box. C. R. D'E.

1770. *Lane Steam Carriage.* (Horseless Age, 8. p. 153, May 15, 1901.)—This carriage is constructed on the lines now common in American light steam vehicles. The framework of the carriage body encloses and supports a light vertical fire tube boiler and a high-speed vertical engine, together with water and petrol tanks and all accessory parts. The carriage body is sprung from a light tubular underframe, the front tube of which forms the axle, at the ends of which are pivoted the steering wheels, while the back frame tube is split to enclose the halves of the live rear axle, which is driven through the differential gear. The boiler is 16 inches diameter by 20 inches high, and contains 500 vertical fire tubes ½ inch diameter. It is said to steam up to 10 h.p. continuously at 150 lbs. pressure. It is fired by a form of Bunsen furnace using petrol vapour. The supply of petrol is nearly completely cut off by an automatic device when the steam pressure rises above a certain point. The engine has two vertical cylinders, each 3 inch bore by 3¼ inch stroke, and runs up to 1,000 revolutions per minute. All the running parts of the engine are enclosed in an oil-tight chamber, which is speciallv arranged to admit of the chain drive from a sprocket pinion mounted on the crank shaft centrally between the cylinders. This chain drive to the exterior of the differential gear forms the entire transmission, which in these steam vehicles is always very simple. Seven gallons of petrol are carried, which is said to suffice for a run of 35 to 40 miles. The water tank has a capacity of 20 gallons, which suffices for a 20-mile run. The exhaust steam from the engine is led into the water tank and thence escapes into the atmosphere. The weight of the runabout type of carriage is 850 lbs., and of the Surrey type for four persons, 1,250 lbs. C. R. D'E.

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[1] Electric Automobiles are described in the section dealing with Electric Traction.

1771. *Motor Vehicles for Heavy Traffic.* **E. Shrapnell Smith.** (Automotor Journal, 5, pp. 403–405 ; Discussion pp. 405–406, May, 1901. Paper read before the Liverpool Chamber of Commerce, May 6, 1901.)—The author refers to past trials of heavy steam vehicles, and the desirability of increasing the tare limit. He has collected all the obtainable data as to the actual cost of the working of steam lorries in practical use, and from these has compiled the following table :—

ESTIMATES OF THE AVERAGE ANNUAL WORKING COST OF MOTOR WAGGONS, ACCORDING TO ROADS AND LOADS.

	CLASS OF WORK.	WEIGHT CAPACITY.	
	Per week } 70 hours under steam. 5½ days. 50 weeks per annum.	Self-contained Motor Waggon, 4 tons.	Motor Waggon and Trailer, 7 tons.
	Prime Cost	£600	£675
	Interest, at 5 per cent. per annum	30·0	33·75
	Deprecation, at 15 per cent. per annum	90·0	101·25
	Fuel—Furnace coke, at 15s. per ton	63·0	94·5
	Wages—Driver, at 35s. per week	91·0	91·0
	Assistant, at 17s. 6d. per week	—	45·5
	Repairs and adjustments	75·0	90·0
	Water, lubricants, and sundries	20·0	25·0
	Insurances	12·0	15·0
	Total per annum	£381·0	£496·0
	Vehicle-miles per annum (280 days)—		
	(A) On bumpy and badly-paved roads, 30 miles per day	8,400	8,400
	(B) On average granite sets, &c., 35 miles per day	9,800	9,800
	(C) On good macadam, 45 miles per day	12,600	12,600
	Net ton-miles per annum—		
A	with full load	33,600	58,800
	,, ¾ ,,	25,200	44,100
	,, ½ ,,	16,800	29,400
B	,, full ,,	39,200	68,600
	,, ¾ ,,	29,400	51,450
	,, ½ ,,	19,600	34,300
C	,, full ,,	50,400	88,200
	,, ¾ ,,	37,800	66,150
	,, ½ ,,	25,200	44,100
	Cost per net ton-mile—	d.	d.
A	with full load	2·7	2·0
	,, ¾ ,,	3·6	2·7
	,, ½ ,,	5·5	4·0
B	,, full ,,	2·3	1·7
	,, ¾ ,,	3·1	2·3
	,, ½ ,,	4·7	3·5
C	,, full ,,	1·8	1·3
	,, ¾ ,,	2·4	1·8
	,, ½ ,,	3·6	2·7

C. R. D'E.

1772. *Brancher Change-speed Gear.* (Locomotion Automobile, 8. pp. 296–298, May 9, 1901.)—In this article a new and ingenious form of gear is described in which the variation of speed of the driving road wheels is obtained by a system of cranks and levers without the direct interposition of toothed gearing. It is applied to a motor vehicle in the following manner. An engine placed at the front of the under-frame drives a cranked shaft at the back of the driving axle of the carriage by means of a long belt. Between this cranked shaft and the axle, and at a higher level, is another shaft, upon which are pivoted two levers. The back ends of these levers are coupled by connecting rods to the cranks on the shaft driven by the engine. The levers are forked towards their front ends, and between the forks are blocks free to slide along the length of the levers and controlled as to position by means of long screwed rods which work in the blocks. These screwed rods are under control of the driver, and are actuated through a system of spur and bevel wheels, so that by rotating them he can cause the sliding blocks to be screwed up close to the shaft on which the forked levers are pivoted, or to move to the extremities of the levers. On each of the sliding blocks are pivoted two levers, like the blades of a pair of scissors; these levers at their lower ends actuate free-wheel clutches on the driving axle of the carriage. As the rocking levers move upwards, these scissor levers close, and as they descend the scissor levers open and cause the axle to be rotated. According as the sliding blocks are close to or far from the point at which the rocking levers are pivoted, the scissor levers will be given a small or large range of opening and closing movement, and the axle will be turned through a corresponding portion of a revolution per turn of the engine. C. R. D'E.

1773. *Transmission Gear for Automobiles.* **H. Austin.** (Automotor Journal, 5. pp. 382–388, May, 1901. Paper read before the Cycle Engineers' Institute, London, May 9, 1901.)—In this paper the author reviews the chief systems of transmission gear at present employed upon motor vehicles propelled by internal combustion engines. The Panhard, Benz, Peugeot, Dietrich, Renault, Dion, and Wolseley systems are illustrated and described. The analysis of the merits of each system is made under the following headings: (1) Efficiency, (2) Adaptability, (3) Simplicity, (4) Lightness, (5) Durability, (6) Manipulation, (7) Cheapness. The general conclusions of the author are, that in spite of its crudeness, the best method at present available of obtaining change of speed is by spur wheels brought into engagement by side contact. The best method of transmitting the power from the change-speed gear to the driving road wheels is by chain gears to wheels which run independently on a fixed axle. All the shafts should be parallel, and at right angles to the length of the vehicle, so avoiding the use of bevel gearing. The connecting gear between the shafts should, as far as possible, be flexible, so avoiding the necessity of an absolutely rigid under-frame. C. R. D'E.

1774. *Tractive Force Required in Automobiles.* **W. F. D. Crane.** (Elect. World and Engineer, 37. pp. 926–928, June 1, 1901.—The coefficient of traction K, or the resistance to motion, depends on the tyres, the road surface, size of wheels, speed, weight, friction losses in hub bearings, and (in the case of electric cars) in motors and gearing. Other things being equal, K should vary inversely as the diameters of the wheels. On hard roads with iron tyres at slow speeds, K has been found to increase somewhat with speed, but not in direct proportion; width of tyre seems immaterial. Under city conditions, unless the machinery be unusually inefficient, the character and condition of the tyres will be more influential in determining K than the nature and condition of the road surface. For horse-drawn iron-tyred vehicles, K has been found to have the following values :—

	Lbs. per ton.
Loose sand	320
Good clay roads	98
Cobblestone	54
Best gravel (park road)	51
Poor block pavement	42
Best macadam	38
Poor asphalt	26

The author has made tests of representative electric vehicles to determine (*a*) the gross value of K, including the inefficiency of the motors, friction losses in gearing and hub journals, rolling friction of tyres, electric losses in wiring, &c.; and (*b*) the net value of K, *i.e.*, the coefficient of traction due to the tyre *per se*. It was assumed in the tests that all pneumatic tyres were fully inflated to about 80 lbs. per square inch for the 2½-inch tyres, 100 lbs. for the 3-inch, and 120 lbs. for the 4 and 5-inch tyres. In the cars tested, the efficiencies of the motors ranged from 79 to 85 per cent., with an average of 81 per cent. Friction losses in gearing were assumed to be 8 to 10 per cent., a figure based on tests of the arrangement of two gears and two pinions, common to all the vehicles. An allowance of 2 per cent. was made in certain cases to cover friction losses in plain sleeve bearings, wiring losses, &c. No account was taken of wind resistance. The results were as follows :—

K in lbs. per ton.		Vehicle.		Sizes and kinds of rubber tyres.	Sizes of Wheels.		City pavements in good condition.
Gross values.	Values for tyres.	Weight in lbs.	Speed m.p.h.		Front.	Rear.	
66	49	1790	14·00	3 in. pneumatic	28	28	Macadam
66	52	1775	13·81	3 ,, ,,	28	28	,,
55	39	2730	12·45	3 ,, ,,	32	36	,,
68	52	3140	11·67	3 ,, ,,	36	36	,,
64	47	1870	15·30	2½ ,, ,,	28	32	Asphalt
64	46	5380	9·00	4 ,, ,,	36	36	,,
54	40	4400	11·20	2½ ,, solid	36	36	,,
48	35	5425	11·15	2½ ,, ,,	36	42	,,
59	43	7240	7·30	3 ,, ,,	38	42	,,
58	42	7240	10·00	3 ,, ,,	38	42	,,
48	36	8480	8·20	4 ,, ,,	38	44	,,
53	38	4150	11·90	2½ ,, ,,	36	42	Macadam
71	51	4300	10·50	5 ,, ,,	36	36	Asphalt
52	37·5	5390	12·60	3 ,, solid in front 4 ,, pneumatic in rear	36	36	,,
55	39·5	5390	11·90				
59	42·5	4150	11·15				
48·5	36	5780	9·75	3 ,, sectional	36	36	,,
38·5	28·5	7900	9·05				

The solid rubber tyres, which show the lowest K, had the shortest lives.

For town roads, a safe figure for K (nett) is 45 lbs. per ton, or say 60 lbs. gross. In country roads, figures may easily be doubled. The tractive h.p. per ton of vehicle is given by the formula—

$$\text{H.p.} = (WSK \pm W \times 2{,}000 \times \sin a) \div 33{,}000,$$

where— W = loaded weight of vehicle in tons of 2,000 lbs.
S = speed in feet per minute.
a = angle of grade.
K = coefficient of traction of vehicle in lbs. per ton.

Or we may simplify this to the following :—

$$\text{H.p.} = (WS'K \pm WS'G \times 20) \div 373,$$

where—
$S' =$ speed in miles per hour.
$G =$ grade expressed as a percentage.

A table calculated from this formula is given for speeds from 1 to 60 m.p.h., and contains the following results :—

Miles per hour.	Tractive Horse-power per ton.				
	On level.		On grades. (The light figures are the *additional* h.p. per ton on grades. The heavy figures are the total h.p. per ton with K = 60.)		
	K = 10.	K = 60	1 per cent.	5 per cent.	9 per cent.
1	0·026	0·16	0·053 **0·213**	0·266 **0·426**	0·48 **0·64**
5	0·133	0·80	0·266 **1·06**	1·33 **2·13**	2·4 **3·2**
10	0·266	1·6	0·533 **2·13**	2·66 **4·26**	4·8 **6·4**
20	0·533	3·2	1·06 **4·26**	5·33 **8·53**	9.6 **12·8**
40	1·06	6·4	2·13 **8·53**	10·6 **17·0**	19·2 **25·6**
60	1·60	9·6	3·20 **12·8**	16·0 **25·6**	28·8 **38·4**

The gross value of K for any vehicle can be found by use of the above formula, if weight, speed, volts, and amperes are known.

For moderate speeds, air resistance is usually neglected, but for a vehicle weighing one ton and presenting 10 square feet of surface, at 35 m.p.h., the power required to overcome air resistance alone will exceed that required to propel the vehicle on the level with K = 60. The pressure of the wind, blowing at right-angles to a flat surface, is given by $p = 0{\cdot}005V^2$, where $p =$ pressure in lbs. per square foot and $V =$ speed in miles per hour. Thus we get the following table :—

Wind Resistances per square foot.

Miles per hour.	Pressure in lbs. per square foot.	Equivalent h.p.
5	0·125	0·0016
10	0·50	0·0133
15	1·125	0·0452
20	2·0	0·1066
25	3·1	0·208
30	4·5	0·360
40	8·0	0·853
50	12·5	1·67
60	18·0	2·88

E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

1775. *Edison's Alkaline Storage Battery.* **A. E. Kennelly.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 331-342, May, 1901.)—The negative active material of this accumulator consists of finely divided iron; the positive active material of a finely divided superoxide of nickel; and the electrolyte of a 20 per cent. solution of potassic hydrate. On discharge the iron oxidises, while the nickel oxide is reduced to a lower state of oxidisation, but the potassic hydrate takes no part in the ultimate products of discharge at either electrode, and the quantity of electrolyte required is therefore very small. The processes employed for the preparation of the active materials are not indicated, nor the compounds of iron and nickel from which they are obtained; but it is claimed that those actually used are the only ones which will give any results, and that all others can neither be reduced nor oxidised electrolytically in an alkaline solution. The active materials are mixed with a nearly equal volume of flake graphite and moulded under pressure into thin rectangular cakes 3 in. × ½ in. Each cake is enclosed in a very thin sheath of perforated nickelled steel, and they are built up into electrodes by placing a number of them in slots in a thin sheet grid of the same metal and clamping rigidly together in a hydraulic press. The graphite is used to improve the conductivity of the active materials, and does not take any part in the cell reactions. Discharge curves are given of a small experimental cell, and the following figures relate to its performance:—

Initial voltage of discharge after recent charge............	1·5 volts.
Mean voltage of full discharge about	1·1 „
Normal discharge current per square foot of active element (positive or negative).............................	8·64 amperes.
Storage capacity per lb. of total cell weight..................	14 watts.

E. J. W.

1776. *Cadmium-Copper Accumulator.* **R. Gahl.** (Zeitschr. Elektrotechn., Wien, 19. pp. 205–206, April 28, 1901.)—The author describes experiments made with a spongy cadmium plate of 0·28 sq. dm. placed between plates of cuprous oxide. The electrolyte was a solution of potash at its best conductivity. The cell was charged and discharged at various rates. The highest e.m.f. obtained was 1·3 volts, but the working value was less than 0·4 volt. With so low a pressure it cannot compete with lead accumulators.

W. W. H. G.

1777. *Lead Burning with Compressed Gases.* **M. U. Schoop.** (Zeitschr. Elektrotechn., Wien, 19. pp. 224–227, May 5, 1901.)—The author describes the use of hydrogen and oxygen, compressed in steel cylinders, for lead burning in accumulator manufacture. The gases are compressed to 120 atmospheres, and delivered through a reduction valve made by Dräger of Lübeck. The cylinders are also provided with two manometers, one on the high-pressure side of the valve showing the amount of gas in the cylinder, and one on the low-pressure side for a maximum of 1·5 atmospheres to indicate the pressure of delivery. The best proportion of the gases is 3 of H and 1 of O. A convenient burner for safely mixing and using the gases, also made by Dräger, is illustrated. Electrolytic gases may be used. W. W. H. G.

1778. *Electric Shocks through Water-jets.* **G. Semenza.** (Elect. World and Engineer, 37. pp. 552–553, April 6, 1901.)—In view of the cases in which firemen were reported to have received shocks in directing water-jets on to live conductors, the author carried out some experiments in the laboratory of the Milan Edison Company to determine the minimum length of jet through which a shock is sensible at different voltages. For a jet 12 mm. in diameter, a curve is given between pressure and length of jet; at the maximum voltage employed of 3,600 volts, sensation was perceptible through a length of jet of 3½ metres; the shock was, however, quite endurable for a length of 1 metre. At a low potential of 200 volts no sensation was perceptible until the jet was brought to within an inch of the conductor. In the experiments a fireman held the metallic nozzle of the jet with bare hands, and, with wetted boots, stood near to where the circuit was earthed. From these experiments the author concludes it to be impossible for a fireman in ordinary work to receive shocks from any conductor without actually touching the wire with the nozzle. G. H. B.

1779. *Electromagnetic Coils and Plungers.* **R. Kennedy.** (Elect. Rev. 48. pp. 656–657, April 19, 1901.)—The action of a coil on an internal iron core is considered by treating it as an elementary form of motor. The pull on a conductor in a magnetic field is equal to—

$$F = 0{\cdot}00000685\,CB,$$

where F is the maximum drag on conductors in pounds per foot of length, B the induction in c.g.s. lines per square cm., and C the current carried by the conductor in amperes. In the common arc lamp solenoid, B may reach a value of 625, so that with 10 amperes this would give a pull of 0·04 lb. per foot. The cases are separately considered of a plunger equal in length to the coil, of a plunger longer than the coil, and of a core of horse-shoe form. The author finally describes a very powerful coil and plunger, designed for striking a heavy blow. W. W. H. G.

1780. *Automatic Field-regulator for Shunt-wound Dynamos.* **B. Krausse.** (Elektrotechn. Zeitschr. 22. pp. 395–396, May 9, 1901.)—In this arrangement, there is a toothed wheel connected to the switch-arm of the regulating rheostat, and over this wheel are arranged two oppositely-turned feed-pawls mounted below a balance-beam at equal distances from and on opposite sides of the fulcrum, the balance-beam bearing detents for locking the feed-pawls, so that when the balance-beam is horizontal, both pawls will be held out of engagement with the toothed wheel. The balance-beam is actuated by the damped core of a solenoid connected, for example, as a shunt to the dynamo terminals so that, when the core sinks, one pawl will be released and will engage with the toothed wheel and, when the core rises, the other pawl will be released and engage with the toothed wheel. Between the feed-pawls, which are drawn together by a spiral spring, a lever oscillates driven by a connecting-rod and crank from a small flywheel and having a projection for alternately tripping a second pair of detent-levers, also holding the feed-pawls. By this means, when the pressure rises, one pawl will be released, and will swing into contact with and be actuated by the oscillating lever so as to turn the toothed wheel and rheostat-arm in one direction, and when the pressure falls the rheostat-arm will be turned in the other direction in a similar manner by the other pawl. C. K. F.

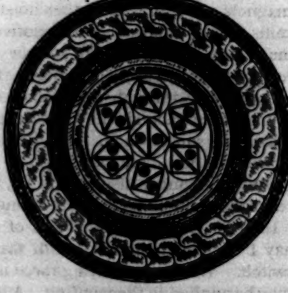
1781. *Switch for Transformers.* **P. Scholtes.** (Elektrotechn. Zeitschr. 22. pp. 361–363, April 25, 1901.)—In this apparatus the main switch of the secondary operates a switch in the primary, and thus the no-load loss is obviated. When the secondary d.p. switch is turned on, a current passes in an auxiliary circuit, including a primary cell and an electromagnet, bridging across one pole of the switch. The magnet moves a trigger which releases an iron weight attached to the primary switch, and at the same time the auxiliary circuit is opened. When the secondary switch is turned off, it momentarily connects across the secondary a solenoid, which pulls up the iron weight and thus opens the primary. At the same time the trigger comes into position, holding off the primary switch and closing one of the two gaps in the auxiliary circuit. The primary is switched off after the secondary, and hence the primary current at breaking is very small. The apparatus is stated to be cheap, and effective in practice. It is made by Schuckert. W. H. E.

1782. *Electromagnets for Lifting.* **E. B. Clark.** (Amer. Electn. 12. pp. 558-560, 1900, and 13. pp. 64–67, Feb., 1901.)—The conditions favourable for the use of lifting magnets, on cranes and other hoists, are most frequently met with in rolling mills, boiler shops, and locomotive repair shops. The material to be lifted must have a fairly smooth surface to which the magnet may be applied. During several years' experience the writer has never known of any accident occurring through unexpected dropping of material. The magnetisation of the polar face should not be carried much beyond $B = 16{,}000$, giving 150 lbs. per square inch. The best form of the magnet depends on the class of work. For plate work a group of rectangular poles answers well. To regulate the number of pieces lifted, the switch should be opened for an instant and then closed again, one or more pieces being thus dropped as required. In order to lessen the effects of self-induction, a non-inductive resistance may be joined in parallel with the magnet coil, on the dead side of the d.p. switch. When extra lifting force is required the series-parallel arrangement may be applied to the winding. A magnet to lift 3,000 lbs. of plates should work with about 1,000 watts, and under favourable conditions such a magnet would lift 10,000 lbs. if the poles fit the material accurately. For cranes used in handling steel plates, the author recommends a magnet made up of, say, twelve poles 3½ inches long and 1 inch by 5 inch cross-section, bolted to a soft-steel plate. On the top of this plate is bolted a smaller one, having an eye riveted to it for supporting the magnet. Each pole is wound to a depth of ¾ inch, no bobbin being required. The poles are arranged in two rows side by side, with poles alternately N and S. This arrangement is for lifting long plates, for which purpose several such magnets may be hung from a long bar. To lift a pile of several small plates at once, the poles should be so arranged as to form practically two large poles, N and S, some distance apart. A magnet on these lines, weighing 300 lbs., lifts 27 times its own weight and requires 4·4 amperes at 250 volts. W. H. E.

1783. *Electrical Tide Indicator.* **G. H. Powell.** (Elect. World and Engineer, 37. pp. 861–862, May 25, 1901.)—A vertical base system of range finding, as required for the guns of a fort on the coast, demands a knowledge at all times of the height above the level of the sea. Hitherto a simple float actuating a hand on a large dial has sufficed. A. Le Blanc has devised an electrical arrangement which is more convenient. The potentiometer principle has been adopted. Between the terminals of a resistance of

120 ohms a constant p.d. of 10 volts is maintained by means of a battery. One end of the resistance is connected with one terminal of a 10-volt voltmeter, the other terminal of which is connected to the slider that is actuated by a float. By providing a suitable scale on the voltmeter the height of the tide is given directly. In the instrument actually constructed the slider is fixed and the resistance moves, being attached to a wheel which is caused to turn as the tide rises or falls. The details of the construction of this resistance are illustrated. W. W. H. G.

1784. *Telephone Cable for St. Gotthard Tunnel.* **A. Baechtold.** (Elektrotechn. Zeitschr. 22. pp. 529–530, June 27, 1901.)—In the design of this cable, special regard had to be paid to the extremely trying conditions to which the cable would be exposed. The water which percolates through the rock and trickles down the sides of the tunnel becomes charged with the acid fumes contained in the smoke from the locomotives, and is highly corrosive. The cable is shown in the accompanying sketch. It is a paper- and air-insulated cable manufactured by Felten and Guilleaume. Each conductor is 1·8 mm. in diameter. There are seven two-wire circuits, each of which is covered with paper tape to a diameter of 7 mm. The seven circuits are stranded together and covered with a triple covering of cotton. A double tin-lead sheathing surrounds the conductors and protects them against the chemical action of the water and acid fumes. Outside the lead sheathing is a layer of compound, and then comes a strong steel armouring of 28 wires, of the special cross-section shown in the sketch. Finally, there is an outer coating of jute-yarn soaked in a protecting compound. The external diameter of the cable is 44 mm. A. H.



1785. *Electric Harbour Cranes at Hamburg.* **E. Krautschopp.** (Zeitschr. Vereines Deutsch. Ing. 45. pp. 654–657, May 11, 1901.)—On the quays at Hamburg there are sixty electrical cranes of from 2½ to 3 tons capacity. The author gives figures showing the power required by them for lifting various loads through various heights, and in particular he deals with the efficiency of the various types. There are six types in all; particulars are given of all of them, showing the methods of regulation, and also the sizes of the motors working them. All are worked by two motors, one for lifting and one for turning. The figures also show the weights unloaded by these cranes and the units consumed during the year 1899 and the first half of 1900; but the heights through which the weights were raised or lowered are not stated. It appears, however, that the best performance was that of a crane which unloaded about 10·2 tons on an average for an expenditure of 1 kw.-hour ; the average height of lift would *appear* to be about 25 feet, the crane being then swung through about 140°, and the load lowered to the ground through a distance of about 10 feet. The author considers that the figures prove : (1) that it is better to use motors too small than too big, and to overload them for short periods, if necessary ; (2) that the weight of the hook and block should be sufficient to allow the chain to descend without the use of current ; (3) that the use of mechanical brakes is liable to lead to waste of energy, inasmuch as there is a tendency on the part of drivers in cold weather to warm themselves by means of the radiated heat from resistances, &c., while regulating the speeds mechanically. The author considers that in the matter of gearing, raw hide pinions are unnecessary. The Union Electricity Company, of Berlin, supplied gearing consisting entirely of steel, very carefully finished, and with proper lubrication the noise is not excessive. Automatic regulation of the height of lift and angle of turning is found by experience to be unnecessary. The cost of working by electricity is not notably lower than that of working by steam, and such small reduction as exists is almost exactly counterbalanced by increased prime cost.

Drawings and descriptions of cranes, similar to those under discussion, constructed by Mohr & Federhaff, and exhibited at the Paris Exhibition, appeared in the Zeitschrift des Vereines Deutscher Ingenieure of June 22, 1901, pp. 874–888. W. H. S.

REFERENCES.

1786. *European Electrical Developments.* **W. J. Hammer.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 105–180, Feb., 1901.)—A paper dealing generally with several modern inventions, &c., including the telephonograph, the Nernst lamp, the osmium lamp, several types of gas and other engines, the Langen mono-rail system, three-phase traction lines, and other developments.

1787. *Automatic Cut-out Switch.* **F. Natalis.** (Elektrotechn. Zeitschr. 22. pp. 318–320, April 11, 1901.)—Description of a new automatic cut-out switch brought out by Schuckert & Co. It is fitted with large carbon contacts and made in seven sizes, ranging from 100 to 2,000 amperes. Three photographs and three line-drawings are given showing details of the construction. E. K. S.

1788. *Carbon for Electrotechnical Purposes.* **J. Härden.** (Elektrotechn. Zeitschr. 22. pp. 320–326, April 11, 1901.)—This article contains a large amount of information as to the methods adopted in the preparation of carbon in its different forms, including the manufacture of electrodes for electrolytic purposes, arc-lamp carbons, carbons for use in the electric furnace, and carbon brushes for dynamos. The author describes tests by which the carbons may be examined in order to ascertain whether they are suitable for the special purposes for which they are intended to be used, and gives figures which he has obtained as the result of these tests. W. H. S.

1789. *Primary Cells with Internal Heating.* **W. S. Rawson.** (Elektrochem. Zeitschr. 8. pp. 25–26, May, 1901.)—This paper describes a cell for molten metals and salts, with arrangement for heating by the introduction of producer or other gases. G. H. B.

1790. *Data of Accumulators.* **J. H. West.** (Electro-Chemist, 1. pp. 70–72, March ; 96–99, April ; and 116–118, May, 1901.)—Tables are given of weight, volume, discharge-rate, and price of various accumulators.

GENERATORS, MOTORS, AND TRANSFORMERS.

1791. *Magnetic Attraction in Armatures.* **E. Knowlton.** (Elect. World and Engineer, 37. pp. 969–970, June 8, 1901.)—Owing to wear of the bearings it is seldom that the armature and the magnetic field of a dynamo are concentric. Calculations are made and formulæ arrived at for the total vertical resultant attraction on the armature when the dynamo has any number of poles. If B be the normal flux density in lines per square inch of a pole face, A the area in square inches of the pole face, g the average normal air-gap in inches, a the normal reluctance of one air-gap, b the normal reluctance of one-half the complete circuit between two neighbouring poles, d the displacement of the armature in inches, and P the vertical pull in pounds, then—

$$P = \gamma \frac{B^2 A}{72{,}134{,}000} \frac{ad}{bg}.$$

For a four-pole machine .... $\gamma = 2$,
„ six- „ „ .... $\gamma = 4{\cdot}7$,
„ eight- „ „ .... $\gamma = 7$,
„ ten- „ „ .... $\gamma = 9{\cdot}6$,
„ $2n$- „ „ .... $\gamma = 2n$,

provided that n be greater than 5. A. R.

1792. *Winding Formulæ for Drum Armatures.* **W. B. Burnie.** (Electrician, 47. pp. 220–222, May 31, 1901.)—Let y_1 and y_2 be the algebraic spacing numbers, that is, if the back connection is from 1 to 18 and the front connection 18 to 3, y_1 and y_2 will be 17 and -15; m the number of entirely independent circuits, n the number of mutually re-entrant circuits, $2p$ the number of poles, N the number of conductors, $b = p$ or 1, according as the armature is series or parallel connected, then—

$$\tfrac{1}{2}(y_1 + y_2) = m\left(\pm \frac{N}{2pm} \pm \frac{n}{b}\right),$$

$\frac{N}{2pm}$ being omitted when lap-winding is used. The value of $y_1 - y_2$ depends on whether we use chord-winding; putting aside chord-winding for the time, $y_1 - y_2 = 0$ for wave-winding, and $= \pm \frac{N}{p}$ for lap. Taking as an example a wave-wound duplex six-pole drum with 102 conductors parallel connected—

$$n = 2,\ m = 1,\ b = 1,\ p = 3,\ \tfrac{1}{2}(y_1 + y_2) = \pm \frac{102}{6} \pm \frac{2}{1} = \pm 15 \text{ or } \pm 19.$$

A particular type of winding can be made out of a given number of conductors, if $\frac{1}{2}(y_1 + y_2)$ is a whole number and the winding is not self-re-entrant before reaching the point where it should be, that is, if $2m$ is the highest common factor of $y_1 + y_2$ and N. For chord-winding the value of $y_1 - y_2$ must be the nearest even number to the fractional or whole number given by the formulæ above. The author gives several more examples of different windings. R. B. R.

1793. *Design of Large Generators.* **A. Heyland.** (Zeitschr. Elektrotechn., Wien, 19. pp. 293–296, June 16, and 305–308; Discussion, pp. 308–310, June 23,

1901. Paper read before the Elektrotechn. Verein, April 24, 1901.)—The author briefly reviews the general principles underlying the design of large modern generators, and compares continuous with alternating-current machines. The maximum output is secured by making the width of the teeth equal to that of the slots. The slots of continuous-current machines should preferably be wide and shallow, the armature reaction may be relatively large (the ratio of field to armature ampere-turns being sometimes equal to unity), and the pole-pieces or pole-shoes should be laminated. In the case of alternators, on the other hand, the windings should preferably lie in tunnels, or else the tops of the teeth should be expanded so as almost to touch each other; armature reaction should be small (ratio of field to armature ampere-turns varying from 3 to 5), and the pole-pieces and pole-shoes should be solid, so as to provide a sufficient amount of damping to prevent hunting. In order to secure stability, the field-cores of dynamos should be worked at a high induction—about 17,000. The peripheral velocity is from 10 to 15 metres per second in the case of continuous-current machines, and 30 metres per second in the case of alternators. A. H.

1794. *Heating of Electrical Machinery.* **E. R. Douglas.** (Elect. World and Engineer, 37. pp. 769–772, May 11, 1901.)—The author gives a mathematical discussion of the problem of the rating of electrical machinery to be used with loads which fluctuate in any regular manner. It is obvious that smaller machines can be used for fluctuating loads than could be used if the load remained at its maximum value throughout. The formulæ given were worked out originally for the Crocker-Wheeler Company, and were tested experimentally with satisfactory results. By measuring the temperature-rise of the coils under various conditions of load, a set of constants is determined for each machine which enables its performance under any regularly recurring loads to be predicted. The rise of temperature for the case of a slow alternation between two conditions of load is considered and an exact solution found. When the period of fluctuation is less than five minutes, an approximate simple formula is given. A. R.

1795. *Dynamo Losses.* **W. Peukert.** (Elektrotechn. Zeitschr. 22. pp. 393–395, May 9, 1901.)—Dynamo losses consist of friction, eddy current, and hysteresis losses. Kapp and others have assumed that frictional losses are proportional to the speed; but Dettmar has shown that they increase more rapidly than the speed. [See Abstract No. 1775 (1899).] According to Dettmar's method, the frictional losses are determined by observing the rate at which the machine, after being brought up to speed, slows down when left to itself, and when running without load or exciting current. Thus we have the equation—

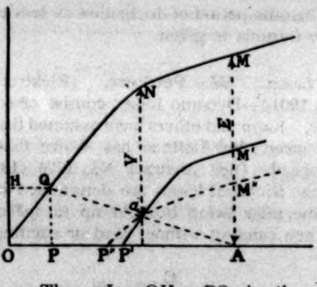
$$R = \frac{C}{t}(v_1^2 - v_2^2),$$

where R is the energy dissipated by friction in a second, v_1 is the initial speed, and v_2 is the speed after a time t, C being a constant that must be determined for each machine. The speeds can be determined by a voltmeter, which shows the voltage of the machine generated by the residual magnetism, a curve connecting the speed with such voltage having been constructed beforehand. Similarly the other losses of the machine can be included and determined by this method, supposing that the magnets remain excited during the period of slowing down. The author experimented with a motor taking

26 amperes at 440 volts, and drew curves showing the rate of slowing down, when the machine was run (1) with no excitation, (2) with one-quarter, (3) with one-half, and (4) with full excitation. The machine was brought up to speed by a small motor, which was then disconnected. The constant C was determined by running the machine with full excitation on no load, and observing directly the power required. By comparison with earlier observations, the constant C was calculated, and the mean of several calculations (which are given throughout in full) in the case of this machine gave its value as 0·006. The previous curves are then corrected so as to give the connection between the losses in watts and the speed at any instant. Finally, the author dissects the losses in one particular case in a manner similar to that proposed by Kapp in 1891. It is stated that the tests can be carried out in a short space of time, and they have always given satisfactory results in the author's laboratory. W. H. S.

1796. *Insulating Armature Stampings with Graphite.* **F. Leconte.** (Électricien, 21. pp. 201–203, March 30, 1901.)—Blacklead is a sufficiently bad conductor for this purpose, and it has the advantage that it is exceedingly cheap and easily applied by machinery. It gives 4 per cent. increase in the quantity of iron which can be packed in any volume (compared to paper insulation). Four per cent. less watts were wasted in running a small graphite-insulated armature on open circuit than when paper-insulated. M. O'G.

1797. *Leakage Reactance of Alternator Armatures.* **A. Blondel.** (Elektrotechn. Zeitschr. 22. pp. 474–475, June 6, 1901.)—The author describes a simple method for separating the effect of armature reaction from that of leakage reactance. Let QNM be the open-circuit characteristic, AM corresponding to the open-circuit e.m.f. due to the ampere-turns OA. Let the short-circuit current corresponding to the same excitation be I_s, and the leakage reactance ω. Then $\omega I_s = OH = PQ$ is the e.m.f. required to balance the leakage counter-e.m.f. In order to produce this e.m.f., an effective excitation represented by OP ampere-turns is required; hence AP gives the back-turns of the armature. If now the machine is allowed to work on an inductive load (power-factor = 0) with a current $I_l = aI_s$, the terminal p.d. is easily found by laying off $Aa = aAQ$, and drawing aN parallel to the axis of e.m.f.; aN gives the terminal p.d. This construction suggests a simple experimental method of finding ω and the factor K which converts armature current into armature back-turns. Find the open-circuit and short-circuit characteristics, and the terminal p.d., V, corresponding to



any current $I_l = aI_s$ when the machine is working on an inductive load. Plot a curve $P'aM'$ which is the open-circuit characteristic QNM lowered by an amount $= V$. Further, plot another curve, $P''aM''$, similar to QNM, the point A being the centre of similarity. The intersection a of these two curves determines the line AQ, and $PQ = OH$. Hence $\omega = \frac{PQ}{I_s}$; and $K = \frac{AP}{I_s}$. The point M must be chosen beyond the knee of the open-circuit characteristic.

A. H.

1798. *Effect of Peripheral Velocity on Dimensions and Weight of Three-phase Generators.* **A. Siewert.** (Elektrotechn. Zeitschr. 22. pp. 462–465, June 6, 1901.)—In this investigation, the author assumes that the revolutions per minute, the frequency, the inductions in air and iron, the flow of current per cm. length of armature periphery, and the ratio of pole-arc to pole-pitch are given, and considers how the weight and external dimensions of the machine depend on the peripheral speed. He finds that a reduction of weight with increase of peripheral speed can only be obtained if the output of the machine is not too small. A. H.

1799. *Distribution of Potential in Short-circuited Three-phase Generators.* **E. Rosenberg.** (Elektrotechn. Zeitschr. 22. pp. 357–361, April 25, and 377–379, May 2, 1901. Report read before the Hanover Elektrotechn. Verein, Jan. 22, 1901.)—When a single-phase alternator is short-circuited, the e.m.f. in any section of the armature-winding is balanced by the fall of potential along the same section. In the case of star-connected three-phase generators, this statement does not hold good. Experiment shows that there may then be a considerable p.d. between the neutral point of the winding and the short-circuiting conductor, and that if these two be connected by a stout conductor (an ammeter being included in the circuit), a considerable current will flow through this conductor. Curves obtained with several different machines are given which exhibit this effect very clearly. The explanation is to be found in the presence of a third harmonic in the e.m.f. wave. The author describes a number of experiments, all of which go to prove the fact that the frequency of the current obtained in the conductor connecting the neutral point with the short-circuiting conductor is three times the frequency of the current in each phase. A detailed graphical discussion of the effect is given. In the directions issued to fitters, it is frequently stated that when running the machine on short-circuit, in order to heat up the coils before a test under load, the rise of temperature may be estimated by placing the hand in contact with the coil, and that there is no danger in doing this. The author points out that in the case of many three-phase machines such a procedure might be attended with danger to life. A. H.

1800. *Voltage-Drop in Three-phase Alternators.* **J. Rey.** (Ind. Élect. 10. pp. 221–227, May, 1901.)—The author calculates the voltage-drop in a three-phase inductor machine and compares his results with those obtained by experiment. The theory he adopts is that of "two reactions" worked out by Blondel. [Abstracts Nos. 336 and 337 (1900).] The total magnetic flux is supposed to be the resultant of two fluxes, one due to the ampere-turns in the inducing circuit and the other due to the ampere-turns in the induced circuit. The flux induced by the latter is resolved into two components, one due to the "wattless" and the other due to the "watt" current: the former current differs 90° in phase from, and the other is in phase with, the total induced e.m.f. The flux induced by the wattless current is in direct opposition to the phase of the total e.m.f., and its effect can be expressed by a certain number of demagnetising turns. On the other hand, the watt current gives rise to a transverse magnetic force, and the flux has to be calculated from the reluctance of a different magnetic circuit. The effect of this transverse flux is analogous to self-inductance. The 60-kw. machine experimented on gave a p.d. of 3,000 volts per phase. There were three air gaps in the magnetic circuit, and so Blondel's theory was severely tested. All the dimensions and calculations are given in full, the slots being taken into account and the variation of the reluctance for various positions of the inducing poles duly noted. The direct reactance varied between 178 and 213 ohms, whilst the transverse varied between 117 and 136 ohms. The mean of the first two and the mean of the last two figures were taken in making the calculations. The following results show that the theory was very approximately correct for this machine on a non-inductive load.

Exciting Current in Amperes.	Main Current in Amperes.	P.D. at Terminals per Phase in Volts.	Total e.m.f. calculated by Two-Reaction Theory.	E.m.f. measured from characteristic on Open Circuit.	Percentage Error.
11·2	3·98	2020	2276	2240	+1·6
14·8	4·71	2410	2730	2730	0
17·8	5·08	2640	3010	3020	−0·3
20·0	5·35	2780	3170	3180	−0·3
25·0	5·55	2900	3330	3380	−1·5

A. R.

1801. *Compounding of Alternators by Compensating Exciter.* **E. J. Berg.** (Elect. World and Engineer, 37. pp. 676–678, April 27, 1901.)—This is a description of a device, due to E. W. Rice, jun., which consists in directly connecting an exciter synchronously with the generator and exciting this exciter by the current from the alternator. An alternating current supplied to such exciter armature will magnetise the machine and cause it to give any desired direct-current voltage, which depends not only upon the magnitude of the current, but also upon its phase relation to the field poles. W. G. R.

1802. *Polyphase Substation Machinery.* **A. C. Eborall.** (Inst. Elect. Engin., Journ. 30. pp. 702–753; Discussion, pp. 753–772, May, 1901.)—Polyphase substations can be divided into three classes, viz.: (1) those employing asynchronous motor-generators; (2) those using synchronous motor-generators, and (3) those using rotary convertors. Of these, the first are the simplest both in design and operation, and the third are the most complicated, owing partly to the necessity of transforming the pressure before putting the current through the rotaries and to the nature of the regulating devices. The methods of starting the various types of machine are considered in detail. [See also Abstract No. 2102 (1900).] With rotaries there is an advantage in connecting the transformers in mesh, because if one transformer should blow its fuse, the other two will continue to supply three-phase current to all three phases of the rotary. If the transformers were connected in a star, single-phase current only would be delivered, and the rotary would probably have to be cut out owing to sparking on the commutator.

The six-phase connection for rotary convertors is desirable, seeing that the output of a six-phase rotary is from 40 to 50 per cent. greater than that of a three-phase rotary, allowing the same mean heating in the armature coils. The connections for this system are illustrated by diagrams, but admittedly the arrangement is complicated. For regulating the pressure of rotaries, two methods are available : (1) a method by which the impressed pressure is varied by an induction regulator, which is conveniently done by hand in the case of a lighting load ; and (2) a system of compound winding of the rotaries, which is more suitable for the case of a traction load. Both these methods are fully explained and discussed. Substation machinery of the synchronous type has the great advantage that the lagging current can be controlled by varying the excitation, and that it is smaller in amount than with the asynchronous type. The connection of this matter with the design of the machine is explained by the aid of curves which show the performance of a synchronous motor-generator made by Kolben for the Prague tramways. Drawings are also given of this and other machines. Synchronous motors should be so designed that, when run as generators, they have a drop at full load at 5 or 6 per cent. with a power-factor of 100 per cent., and of 18 to 20 per cent. with a power-factor of 80 per cent. The question of parallel-running and hunting is of importance. Difficulties often arise from the cyclic irregularity of the engines, and the author considers that the Horn tachograph (sold by Berend, of London) should be more widely used by engine-builders and others in this country. Curves taken by this instrument are reproduced, showing the variations in speed of an engine while its governor was undergoing adjustment. In designing the engine-room plant, the better plan is to place the generator between the cranks, which should be at 180 degrees apart. On the Continent horizontal engines are being standardised with tandem cylinders and one crank. This arrangement gives the fewest points of maximum and minimum speed per revolution. The amount of cyclic irregularity, with rotary converters for example, should be such that the phase-displacement at any time should not exceed 2 degrees, that is to say, a point on the rotating magnet should not differ by more than $2/p$ degrees from the position it would have if the rotation were perfectly uniform, $2p$ being the number of poles. The machines themselves help to increase any irregularity of speed under various conditions, and the armature oscillations should, therefore, be damped as soon as they arise. For this purpose the author recommends damping coils, which bridge the poles of synchronous motors and rotaries by copper plates. He considers that it is of relatively little use to put the damping coils round the pole-pieces ; this view was, however, considered unsound by some of the speakers in the discussion, while others favoured the use of Leblanc's "amortisseurs." Synchronous motors, on account of armature reaction, are less liable to hunt than rotary converters ; but this is also due partly to the fact that the fields are fed at a steady pressure, independent of the pressure on the feeders. As the result of hunting, the current in the high-pressure feeders pulsates ; at Prague this has been obviated by the insertion of choking coils in the feeders. When working at no load without choking coils, the fluctuation of pressure was about 8 per cent. ; when the coils are in circuit, no fluctuation can be detected. With a choking coil for use with a 900-kw. machine, the loss at full load in the coil was 800 watts, and the pressure drop was about 2 per cent. Finally the author gives a table comparing the various types of machinery for substations from the point of view of the performances of the machines, in so far as these can be numerically dealt with. This table is reproduced on the next page.

COMPARISON OF SUBSTATION MACHINERY.

Transmission : Three-phase at 5,500 volts between lines and 40 cycles.

Distribution : Three-wire at 510 volts between outers, neutral conductor earthed.

Type of Equipment.	Asynchronous Motor generator.		Synchronous Motor generator.		Rotary Converters and Step-down Transformers.	
Output of substation converter	150 kw.	500 kw.	150 kw.	500 kw.	150 kw.	500 kw.
Speed of converter...	480	300	480	300	480	300
Number of field-poles (generator) ...	6	10	6	10	10	16
Peripheral speed of commutator ...	1760	1880	1760	1880	2970	3100
Number of commutator bars	162	270	162	270	400	560
Temperature rise, any part after 24 hours at full load...	35° C.	35° C.	35° C.	35° C.	35° C.	35° C.
Rise of pressure when full load switched off, substation bus-bar pressure constant	15%	12%	14·5%	11·5%	9·5%	8%
Efficiency Full load	83·5%	86%	84%	87%	90%	92%
Half „	75·5%	80%	76%	79%	85%	87·5%
Overload capacity for one hour with fixed brushes ...	25%	25%	25%	25%	50%	75%
Power-factor Full load	90%	91%	100–95% (leading)	100–96% (leading)	100–95% (leading)	100–96% (leading)
Half „	87%	88%				
Starting current from A.C. side in terms of full-load current	80% (Rotor resistance.)	50% (Rotor resistance.)	100% (Starting motor.)	100% (Starting motor.)	80% (Starting motor.)	60% (Starting motor.)
Full load drop of speed	3·5%	3%	None	None	None	None
Relative cost per kw., including regulating gear ...	20	15·6	19·1	13.2	12·4 (Including middle wire booster.)	13·0 (Including middle wire booster.)
Floor space required per kw. (square feet)	0·8	0·5	0·75	0·5	0·55	0·45

W. H. S.

1803. *Resistance of Squirrel-Cage Rotor.* **J. Heubach.** (Elektrotechn. Zeitschr. 22. pp. 430–432, May 23, 1901.)—The paper contains a very elegant method of investigating the apparent increase in resistance of the rotor bars which is due to the resistance of the end-rings. It is assumed that the space-distribution of the magnetic flux follows the simple sine law. The author first supposes that the resistance of the rings is negligible. The current flowing in each rotor bar will in this case simply correspond to the e.m.f., and we accordingly get a sine-distribution of currents. He next assumes the whole of the resistance to be in the end-rings, the bars being without resistance. If we suppose the whole of the resistance to be concentrated in one ring, the resistance of each segment of this ring must, for the purposes of calculation, be assumed equal to double its actual resistance, and the p.d. across a segment of the ring between two neighbouring bars will equal the difference in the e.m.f.'s induced in these bars. The law according to which the currents are distributed in the end-rings is thus obtained. A combination of these two ideal cases corresponds to the actual rotor. Using this method, the author shows that if R_b is the resistance of a rotor bar, and R_r = that of a single segment of the ring, then the current in each bar is that corresponding to a resistance—

$$R_b + \frac{R_r}{2\sin^2\frac{\alpha}{2}}$$

where α is the angle of phase-difference corresponding to the angular distance apart of two consecutive bars. He then applies this result to determine the best way of arranging a given amount of copper, and shows that if Q = cross-section of ring, and q = cross-section of bar, then the least resistance is obtained by making $\frac{Q}{q} = \frac{1}{2\sin\frac{\alpha}{2}}$.

A. H.

1804. *Frequency Converters.* **A. S. McAllister.** (Elect. World and Engineer, 37. p. 763, May 11, 1901.)—The adoption of a frequency of 25 for power transmission has led to the use of "frequency converters" when the supply is to be used for lighting. The frequency converter consists practically of a combined synchronous and induction motor. The supply current is derived from the rotor of the induction motor which is driven backwards by the synchronous motor. If a load of W kilowatts is to be changed from a frequency p to a frequency q, then the capacity of the induction motor should be $\frac{p}{p+q}$W, and of the synchronous motor $\frac{q}{p+q}$W. It is to be noted that the iron loss in the rotor will now be the same as that of a generator whose capacity is W kilowatts and frequency q. Hence it will be an appreciable quantity.

A. R.

1805. *Rotary Converters.* **de Marchena.** (Soc. Int. Élect., Bull. 1. pp. 205–244; Discussion by **P. Janet,** pp. 244–245, May, 1901.)—The ratio of the direct and alternating current voltages, the heating of the armature, and the armature reaction are calculated for all cases. It is proved that when the number of phases is infinite and the current is in phase with the applied e.m.f., then the armature reaction is zero. When the angle of phase-difference between the current and the e.m.f. is ϕ, then the wattless component I sin ϕ produces a magnetising force in the same direction as that produced by the exciting coils. This magnetising force tends to strengthen the magnetic field when the current is lagging and to weaken it when the current is leading. Hence in a converter, as in a synchronous motor, strengthening the field makes a leading current and weakening the field makes it lag. The author develops this analogy, and points out that it is possible to make converters which will act without excitation. The capacity of such machines would be small, as the current would need to lag by a considerable angle. In practice the number of phases is limited, and hence the magnetic field is not constant. For a single-phase converter the field produced by the armature is a pulsating one whose frequency is double that of the current supplied. When there are *n* slip-rings the frequency of the pulsations is *n*, but their amplitude diminishes rapidly with *n*. The stability of converters and their capacity to stand overload is favourably commented on. A mathematical discussion is given of their regulation, and it is shown theoretically and by experimental results with a 800-kw. converter that practically constant volts at all loads can be obtained by putting a regulating induction coil in series with the converter. To prevent "hunting," copper plates should be put between the poles, and the converters ought never to be started directly in parallel without special devices to prevent a rush of current. A. R.

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1806. *Rotary Converters and Motor Generators.* **F. C. Perkins.** (West. Electn. 27. pp. 364–365, 380–381, 396–397, and 412–413, 1900.)—An illustrated account of the various uses of these machines. W. H. E.

1807. *Calculation of Leakage Coefficients of Induction Motors.* **J. Jones.** Elektrotechn. Zeitschr. 22. pp. 448–451, May 30, 1901.)—The author develops formulæ for the leakage coefficients of induction motors, taking the case of slotted cores. The method used in deducing the formulæ is explained in detail, and several interesting examples of the application of the formulæ to actually constructed motors are given, which show that the calculated values agree very closely with those found experimentally. A. H.

1808. *Formulæ for Leakage Inductance in Alternators.* **Niethammer.** Elektrotechn. Zeitschr. 22. pp. 475–476, June 6, 1901.)—The author gives a theoretical formula for the leakage inductance, and proceeds to show how the theoretical values for the constants entering into the formula have to be modified in order to bring them into agreement with experimentally determined values. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1809. *Polyphase Equipment of Factories.* **W. Wyld.** (Inst. Elect. Engin., Journ. 30. pp. 986–1011; Discussion, pp. 1012–1019, June, 1901. Paper read before the Birmingham Section of the I.E.E.)—The author deals with the advantages and disadvantages of polyphase motors for workshop purposes, and considers them to give as good results as continuous-current motors. He gives a list of sixteen polyphase installations in this country, and describes more particularly that of the Patent Shaft and Axletree Co., Wednesbury. In this factory the generators, which are star-wound, give current at 350 volts; the lighting is, however, carried out at 200 volts by connecting the lamps to the neutral wire and one or other of the main cables. The load-factor is 42 per cent., and with an output of 554,000 units in the year, the cost of generation, including coal, water, wages, oil, and stores is 0·552d. per unit, and the cost of distribution, *i.e.*, the wages of motor attendants, crane men, arc-lamp trimmers, &c., amounted to 0·215d. per unit, making a total of 0·767d. per unit. The works contain two travelling cranes, the speeds being controlled by resistances introduced in series with the rotors. Ten additional cranes are to be similarly fitted with motors and controllers. The author, in conclusion, gives a long list of factories abroad which are worked by polyphase motors, adding at the same time concise particulars about each.

Discussion.—**W. E. Sumpner** said that owing to the absence in polyphase motors of exposed parts connected to the mains, a higher voltage than that used with direct-current motors was equally safe, and that the advantage as regards economy of copper for distribution in factories lay decidedly with polyphase systems. **H. D. Wilkinson** said that in collieries, and places where the current had to be conveyed over any considerable distance, the regulation obtainable with direct current was very unsatisfactory, and that polyphase current was far more suitable. **A. M. Taylor** considered that in cases in which current might eventually be supplied from some large power scheme, polyphase motors should be put in, as it was doubtful whether in such power schemes it would pay to put in rotary converters. Other speakers advocated direct current, and some pointed out that the difficulty of speed regulation, in connection with polyphase motors, was generally in practice of very minor importance. W. H. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1810. *Grimsby Electricity Works.* (Electrician, 47. pp. 127–131, May 17, 1901.)—This station has been designed by Kennedy on the direct-current system. The boiler-house contains three Lancashire boilers 28 feet by 8 feet; each boiler has a steam drum 2 feet in diameter and 8 feet long. The economiser contains 144 tubes. The chimney is 180 feet high, tapering from 13 feet to 11 feet internal bore, with a fire-brick lining carried up to 25 feet. The main steam ring consists of 8-inch pipes; the branch pipes to the engines are in duplicate, one pair of pipes serving two engines. There are at present three steam dynamos, running at

550 r.p.m., having each an output of about 90 kw., and also two small balancers driven by steam. The station will eventually supply the local tramways with power, and for this purpose the machines can be run as shunt machines on the lighting load, or as compound machines on a traction load, the pressure in the latter case being from 500 to 550 volts, and in the former case from 460 to 520 volts. At present two feeders have been laid, one 0·75 square inch, the others 0·35 square inch, in sectional area, the middle wire feeder being 0·1 square inch. In series with the earth current recorder on the lighting board between the middle wire and the earth plate is placed an automatic switch. This switch opens when more than 10 amperes pass, and at the same time throws in a resistance of about 25 ohms between the middle wire and earth, and in parallel with this resistance is a lamp or bell. By this means, even if a dead earth occurs on one side of the network, no serious rise will take place in the pressure on the other side. There is a battery of Tudor cells to take the day lighting load, giving an output of 60 amperes for five hours; the boosters are controlled by Kennedy's usual switching arrangements. There are 78 arc lamps, arranged to run ten in series across a pressure of 460 volts. The article contains a drawing showing a plan and sections of the generating station. The Tramway Company will be supplied at the rate of 1½d. per unit for the first 360,000 units per year, 1⅜d. for the next 100,000 units, and 1¼d. afterwards. W. H. S.

1811. *Ilford Electricity Works.* (Elect. Engin. 27. pp. 735-744, May 24, 1901.)—The supply to consumers is on the three-wire continuous-current system, with 460 volts between the outers. There are three Babcock boilers, each with a heating surface of 2,197 square feet, worked in conjunction with an economiser of 196 tubes. The chimney is 185 feet high, and has an internal diameter of 8 feet at the top. There are three steam dynamos by Willans & Robinson and the General Electric Co., the two larger having an output of 200 kw., and the smaller of 100 kw. They are run as shunt or compound machines, according as they are used for lighting or traction. The switchboard is by Kelvin & White, and is described in considerable detail. There are 270 cells by the E.P.S. Co., discharging at the rate of 200 amperes for three hours. The cables are armoured and laid direct in the ground. The article contains a large number of drawings, including section and plan of the generating station, drawings of different sections of the boiler-house, the connections on the main switchboard, details of the transmission gear for working the accumulator regulating switches, details of the feeder pillars, a drawing of the arc-lamp and tramway poles, and of the base of the tramway poles with switch-gear for arc lamps, and the connections to the arc and incandescent lamps. W. H. S.

1812. *Rotherham Electricity Works.* (Elect. Engin. 27. pp. 770-774, May 31, 1901.)—This station, which was designed by Kennedy, supplies continuous current. It contains two Lancashire boilers, 28 feet by 8 feet, working at 160 lbs. pressure. The engine-room plant consists of two 90-kw. dynamos, two steam-driven balancers, and two motor-driven boosters. The larger dynamos have a compound winding for tramway purposes, and a regulator is placed in the circuit of the series-winding, so that when the two larger machines are worked in parallel, the compounding effect of the series-winding may be altered without affecting the equal division of the current between the dynamos. This is effected by a switch which, in proportion as current is shunted from the series-winding, adds an equivalent resistance in series, thus keeping the resistance between the equalising bar and the negative bar the same as before. The station also contains 256 cells by the E.P.S. Co., discharging at the rate of 50 amperes for five hours. The article contains drawings showing plan and sections of the station buildings. W. H. S.

1813. *Tynemouth Electricity Works.* (Elect. Engin. 27. pp. 806–812, June 7, 1901.)—This station supplies continuous current. It contains three Lancashire boilers, 30 feet by 8 ft. 6 in., the steam being superheated by Musgrave superheaters. The chimney is 150 feet high and 8 feet in diameter, being intended to serve also for a proposed destructor installation. The feed-pumps are electrically driven, the speed being controlled on the series-parallel system, so as to vary from full to one-quarter of full speed. The engine-room contains three 180-kw. sets, giving their outputs at from 445 to 550 volts, according as the power is required for lighting or traction purposes. A further 520-kw. set has been ordered. There is also a battery of 252 cells, giving 60 amperes for 10 hours. Diagrams are given showing the connections on the lighting and traction switchboards. W. H. S.

1814. *Madrid Electricity Works.* **H. Baswitz.** (Elektrotechn. Zeitschr. 22. pp. 425–429, May 23, 1901.)—The station described belongs to the Electricity Supply Co. for Spain, which is the largest of the fifteen different companies operating in Madrid. The station, which is 1¼ miles from the centre of the town, has recently been almost entirely reconstructed by the Union Electricity Co. of Berlin. The rubber cables, which had been used, were to a large extent perished, and the arrangement of the machinery was out of date. The new installation is on the monocyclic system. The boilers have remained unchanged, and consist of Babcock boilers, of which eleven have a heating surface of 1,827 square feet, and four have 3,240 square feet. Spanish coal is used, though inferior in heating capacity to English coal, but the latter is too expensive. A reservoir holding about 700,000 gallons has been constructed to provide water during the period of drought, which lasts about six weeks in summer. The old chimney was 115 feet high, and a second has been erected 165 feet high and of 10 ft. 6 in. diameter. The new machines include four monocyclic generators, giving 450 kw. each, at 2,200 volts and 125 r.p.m., with 50 cycles per second. The engines are compound vertical, and were built by Swiderski, of Leipzig, being fitted with jet condensers. The condensing water is cooled by towers, the water falling 28 feet, and being circulated by centrifugal pumps driven by induction motors. The connections on the switchboard are clearly shown by a diagram, as also the arrangement of switches, instruments, cut-outs, &c. The 20-ton travelling crane has a span of 56 feet. The distributing system was in a state of great confusion, largely owing to the fact that in Madrid the gas, water, and electric light companies are allowed to remove their pipes without being subject to any control, and without consulting one another. It is hoped that this state of affairs is at an end. Lead-covered armoured cables, insulated with impregnated yarn and paper, are now used. There are two main sub-stations, 38 kiosks equipped with transformers, and two underground stations. In all, these contain 70 oil-transformers of 30-kw. capacity, distributing on the three-wire system, with a pressure of 200 volts between the outers. Most of the transformers are switched off at midnight. W. H. S.

1815. *Electrical Development at Manchester, N.H.* (Elect. World and Engineer, 37. pp. 857–861, May 25, 1901.)—The amalgamation of local electrical supply companies has brought about a novel example in electrical distribution. At a substation at Manchester, N.H., energy is received from five generating stations and distributed to four towns. Three of the stations are run by water power, one has both water and steam, and one has only steam. The most distant is *Garvins Falls*, 14 miles from the substation. The plant here consists of four General Electric generators direct connected to the shafts of the turbines. Each has a capacity of 650 kw. three-phase, 60-cycle, at 10,000 volts. At *Hooksett* there are two generators of the same make for 300 kw. three-phase, at 1,000 volts. A part of the energy is distributed locally at 1,000 volts, and the remainder is stepped up to 10,000 volts, and is transmitted to Manchester, 10 miles away. At *Gregg's Falls* the generation is at 10,000 volts, three-phase, by a single General Electric 1,200-kw. generator. This supplies two towns at 2,000 volts, but the bulk of the power is transmitted to the Manchester substation, a distance of 6 miles. *Kelley's Falls* station is three miles from the substation. It has four generators—one 300 kw. three-phase 2,000 volts, by the General Electric Co., and three other two-phase machines. The transmitting pressure is at 6,600 volts for the three-mile line. At *Brook Street* station in Manchester the plant is of a different kind. Three 600-volt generators for railway work of capacities 500, 300, and 200 kw., deliver their energy directly from the station switchboard. This also applies to the arc lighters for 487 lamps in the Manchester streets. There are also four three-phase generators with a total capacity of 1,250 kw., which supply at 2,000 volts to the substation, 150 yards away. Underneath the main floor of the substation is an air-tight basement, which is intended to serve as an air-pressure chamber. Two blowers, each driven by a three-phase motor, maintain the air in the basement at a higher pressure than outside. Over openings in the main floor the necessary transformers are placed, and there is a rapid flow of air through them. The switchboard is of somewhat special design ; it distributes at 2,000 volts and 60 cycles. The system requires 33 miles of overhead lines. Double petticoat *glass* insulators are used. Where the lines pass through the city on their way to the substation they are carried over all other wires.

The collection of energy from these distant sources is making Manchester independent of coal supply. Many hundreds of electrical horse-power are being supplied to manufacturers at a price which has led them to discard steam engines. W. W. H. G.

1816. *Electrical Plant of the Curtis Publishing Company.* **J. S. Griggs, Jr.** (Elect. Rev. N.Y. 38. pp. 417–421, April 6, 1901.)—The new shops of this company in Philadelphia are electrically driven throughout. The powers required by the different machines were very carefully determined by experiments on similar electrically driven presses. The plant, which is a "three-unit" one, any two units being easily capable of taking the maximum load, comprises three 250-h.p. Babcock boilers working at 160 lbs. per square inch with a Green's economiser, and induced draught, which was used owing to the stack being only 30 in. × 40 in. × 90 ft. high. The economiser is found to reduce the coal bill by 8 per cent., and so cools the gases that the power required to run the fans is less than half that required when the economiser is cut out. The induced draught is furnished by one of two 120-inch "American" fans, driven by an 8-h.p. direct-connected motor at any speed from 100 to 275 r.p.m. Normally the fan takes only 3 h.p and the economiser scrapers, which are only run a few minutes a day, take ½-h.p. To increase the economy of working, while utilising exhaust steam for heating, the Webster vacuum return system was installed, whereby the exhaust gauge never exceeds ¼ lb. per square inch. The exhaust steam first passes through a 600-h.p. Cookson heater, and then goes to the buildings, whence the condensation is returned to the feed water heater at about 170°. The make-up feed is automatically supplied from the city mains through a float valve in the heater, and is raised to about 210°, mixed with the returns and fed into the boilers by one of two Gould motor-driven pumps, capable of pumping 40 gallons per minute, and arranged for any desired speed down to one-third of the maximum.

Each press is controlled by two rotary controllers of the tramway pattern. One is a series resistance, used in starting only; the other determines the running speed, and is either wholly a shunt resistance, or partly shunt and partly series, according to the range of speed required. Shunt regulation alone gives a range in the rotary presses from 65 to 85 impressions per minute, and from 14 to 20 on the top-cylinder presses. During one month there were delivered to the switchboard 88,400 kw.-hours, at a cost (including taxes, insuring, interest, depreciation, repairs, &c.) of 1·49 cents. per kw.-hour, which is a quarter of the lowest price obtainable from the Supply Company. E. H. C.-H.

1817. *Combined Electric Lighting and Steam Heating Plant.* **W. N. Zurfluh.** (Amer. Electn. 13. pp. 201–207, May, 1901.)—This plant includes two 400-h.p. boilers, with underfeed mechanical stokers, and 3 six-pole dynamos, of 100 kw. each, compound wound for 120–125 volts at 225 revolutions per minute, driven direct by simple horizontal engines having cylinders 14½-inch diameter and 16-inch stroke. The lighting supply is carried out on the two-wire system. Heating is done both by exhaust steam (entailing a back pressure of 2 to 5 lbs. per square inch, according to the season), and by steam at boiler pressure (120 lbs. per square inch). A. H. A.

1818. *High Pressure Transmission in New York City.* **C. W. Rice.** (Elect. World and Engineer, 37. pp. 899–900, May 25, 1901. Paper read before the National Electric Light Association.)—The author describes in outline the scheme which is being carried out for the electricity supply of New York. Four power-stations are being erected, which are to contain three-phase generators working at 6,600 volts, 25 cycles per second (one station will work at 11,000 volts). The largest station is designed for 125,000-h.p. in 16 sets. Power is to be distributed through cables, some insulated with rubber, others with paper, to substations, where transformers and six-phase rotary converters transform it to direct current, feeding the Edison three-wire system at 135 volts each side. A. H. A.

1819. *The Metropolitan Railway of Paris.* **A. Dumas.** (Génie Civil, 38. pp. 277–293, March 2, 1901.)—On this line there are eighteen stations, at an average distance of 625 metres. The time occupied in stops has now been reduced to 10–15 seconds; acceleration occupies 10 seconds, and braking 15 seconds. This results in an effective speed of 21 km. per hour, with a maximum of 30 km. per hour. In the daytime, trains are run with three minutes headway. The number of passengers per km. per annum is now more than 4 millions, as against 3 millions per km. per annum on the London Metropolitan, 2·8 millions on the Berlin Metropolitan, and 3·15 millions on the Manhattan Elevated. The Central London Railway, 10·5 km. long, carried 14·5 million passengers between July 30 and December 31, 1900. At Paris the tickets are printed at each station by a motor-driven apparatus, which also counts them ; it turns out 240 tickets a minute. No change is given at the booking-office, but the newsvendor is bound to supply it. Automatic signalling is employed, on the Hall block system. Pedals, depressed by the wheels, open switches in relay circuits controlling the circuits of electromagnets at the signals, which cover the signal light with a white or red glass. Diagrams of connections are given in the paper. When a train passes over a pedal it puts the signal at danger, leaving the previous one also at danger, but restoring the third signal behind it to "line clear."

The generating station at Bercy contains four 1,500-kw. generators with transformers and auxiliaries. The 18 boilers are of the semi-tubular type, mechanically fed with coal which is first conveyed 95 m. underground from the barges on an endless moving platform, then raised 24·5 m., weighed automatically in one-ton lots, fed into 60-litre chain-drawn cars, and thence into the hoppers. The apparatus will handle 60 tons per hour, with an expenditure of 20 h.p.-hours, the distance being 200 m., and the difference of level 10 m.

Three of the 1,500-kw. machines supply three-phase current at 5,000 volts and 25 periods. The rotating magnets are of the radial pole type, and take about 1·5 per cent. of the output at full load. The fourth unit is a direct-current 600-volt machine, shunt-wound and guaranteed to give constant voltage within 5 per cent. whatever the load. The stationary magnet has 20 poles ; the armature is slotted and bar-wound. The 65-kw. exciters at 140 volts are driven by 600-volt shunt-wound motors. There are also 200-kw. boosters, capable of raising or lowering the voltage to the extent of 25 volts. These are driven by shunt-wound motors, the booster-generator fields being series-wound. The boosters are intended to act as regulators, making the battery (of 260 Tudor cells, with a capacity of 1,600 ampere-hours at a 1-hour rate) operate in the most efficient way as a "flywheel." Static transformers reduce the 5,000 volts to 430 volts, and rotaries convert this into direct-current at 600 volts. The transformers are air-cooled, weigh 6 tons each, and have their primaries connected in triangle, the secondaries being independent.

At the Place de l'Étoile is a substation containing four 750-kw. transformers and rotaries of the same type as at Bercy ; also a battery giving 1,800 ampere-hours at a 1-hour rate. [See further Abstract No. 2505 (1900).] E. H. C.-H.

1820. *Lisbon Tramway System.* **F. A. Wardlaw.** (Street Rly. Journ. 17. pp. 208–219, March, 1901.)—The tramways in Lisbon are owned by an English company, which at present operates 44 miles of track with about 330 cars and buses, and 1,200 mules : 400,000 passengers are carried per month, with fares from 1d. to 4½d. The gross earnings for 1898 showed a loss of £4,000. Drivers and conductors are paid about 2s. a day. When converting to electric traction, the gauge was altered from 4 ft. 8½ in. to 90 cm. in order to prevent rival buses from taking advantage of the rails. A 91-lb. 7-inch girder rail was used, spiked to ties and cast-welded by the Falk process. Cross bonds were used every 90 feet and between tracks every 300 feet. Owing to the large range of temperatures between day and night, much trouble was experienced with buckled rails, but finally a satisfactory arrangement of clamps was devised. The average conductivity of joints is over 100 per cent. of solid rail. A power station 128 feet by 180 feet is being built for 3,000 kw. There will be six tandem, compound, condensing engines 19 in. and 40 in. by 42 in. stroke, driving G.E. 500-kw. generators at 110 r.p.m. The Babcock boilers will be arranged for superheating 100° F., but it is doubtful if a satisfactory lubricant can be found. Underfeed stokers will be used with bituminous coal. Natural draught will be supplemented by blowers when necessary. Three series-wound return-current boosters and one feeder booster will be coupled in pairs at the ends of two constant speed 500-volt motors. A battery of 260 Tudor cells (1,440 ampere-hours at 480 amperes) will be placed in the basement of the power-house to act as an equaliser and to take night load. Its charge and discharge will be controlled by a compensating dynamo coupled to a 150-h.p. constant speed motor; this machine will be essentially a differentially wound dynamo, having its series field in series with the negative bus-bar between the generators and the feeder circuits, its shunt field across the bus-bars, and its armature in series with the accumulator and the line. It is so wound that, running as an ordinary shunt dynamo, it has a range of from 50 volts to 180 volts, and 1,000 amperes. When running as a differential machine with a current of 3,000 amperes passing through the series field, there is an electrical balance between the series and shunt fields, resulting in zero potential. Should the current in the series field rise to 4,500 amperes, it overcomes the shunt, and a potential of 75 volts in a direction tending to discharge the battery is produced at the armature terminals. If, however, the series field current should fall to 1,500 amperes, the shunt will overcome the series field, and a potential of 75 volts in a direction tending to charge the battery will be produced. This machine will also be provided with a six-point switch shunting the series field, to admit of adjusting the point where the shunt field overcomes the series, by this means keeping the engines always working at their most economical load.

E. H. C.-H.

1821. *Newcastle-on-Tyne Electric Power Works.* (Electrician, 47. pp. 319–327, June 21; 359–364, June 28; and 397–400, July 5, 1901.)—A station has been erected by the Newcastle-on-Tyne Electric Supply Co., for the purpose of supplying further power to their already existing station at Pandon Dene, and for supplying power in bulk to the Walker and Wallsend Gas Co., who undertake its distribution to manufacturers in the districts round Wallsend, for which they have obtained a Provisional Order. The station at Neptune Bank is first described. The Walker Gas Co. originally intended to build for themselves a station on this site; but the Newcastle Supply Co. took over the site from them, on the understanding that they were to supply the original owners with power in bulk in consideration of the transfer. The station was originally designed for supplying three-phase currents at 5,500 volts with a periodicity of 40; but when the station was taken over by the Newcastle Co., it was proposed to increase the pressure in view of the extended area to be supplied. It was, however, found that the saving in copper would be almost counterbalanced by the increased cost of insulation required by the Board of Trade, and the work was therefore carried out on the original lines. The present site at Neptune Bank will only allow of moderate extensions, and a riverside site of 15 acres' extent has therefore been purchased with a view to contingencies. The present station is situated close to a branch of the North-Eastern Railway, and at present contains eight Babcock boilers, each having a heating surface of 4,020 square feet, and superheating the steam through about 100° F. The steam main consists of a single pipe, 7 inches in diameter; there is, however, in addition a smaller steam-pipe from which the feed pumps and smaller engines are supplied. The steam-pipes are of solid drawn steel tube, both tees and valves having cast-steel bodies. All tees of 5 inches and over are made by riveting a branch pipe directly to the main. The chimney is 180 feet high, and is made of riveted steel, lined with firebrick. The economiser contains 280 tubes. The boiler-house and engine-room are each 160 feet long, and 52 feet wide. The floor of the engine-room is 8 feet above the level of the boiler-house floor, 32 ft. 6 in. below the 25-ton crane, and 10 feet below the switchboard gallery. The machinery includes four 700-kw. sets, driven by triple expansion marine engines, giving a three-phase output at 5,500 volts, with a frequency of 40 at 100 r.p.m.; one 1,500-kw. Parsons turbo-alternator; two Belliss engines, each driving two 100-kw. 240 volt continuous current generators; one 50-kw. 240 volt continuous-current generator; and one 150-kw. synchronous motor-generator, transforming to 240 volts continuous current. The larger units are run in conjunction with Wheeler surface condensers, the circulating water being cooled by means of a pond provided with Koerting spray nozzles; by this means 325,000 lbs. of circulating water can be cooled per hour. The station is 350 yards from the river, and 60 feet above its level; it was not, therefore, considered possible to use river water for the condensers. The motor-generator set is designed either for receiving alternating three-phase currents, and delivering continuous current, or *vice versâ;* and all continuous-current machines have both shunt and series windings on the magnets. All the auxiliary machinery is motor-driven. Power is distributed and supplied to consumers on a variety of systems. The substations in the Newcastle area will be supplied with high tension current through three-core cables, each core having a sectional area of 0·25 square inches. These cables are to be laid on the drawing-in system, the conduit having nine ways, each 4 inches in diameter; they will be armoured with steel, in accordance with the regulations of the Board of Trade with respect to alternating high-pressure current. Distribution from the substations will be effected on the three-wire continuous-current system. The Manors substation, for instance, contains two 500-kw. synchronous motor-generators, one 75-kw. asynchronous balancing and starting set, one 25-kw. continuous-current balancer, and a 7½-ton travelling crane; drawings are given, showing the general arrangement of plant in this substation. The Walker and Wallsend Gas Co. also receive power in bulk through three-core cables, each core having a sectional area of 0·15 square inch. The high-tension cables are insulated with bitumenised paper, the thickness of insulation between any conductor and earth being as great as that between any two conductors. The low-tension cables in the Gas Co.'s area are insulated with vulcanised bitumen, the mains being arranged on the three-wire system, and consisting for the greater part of 0·5, 0·25, and 0·5 square inch single conductors. This area contains some very large consumers, for whom special substations on their own premises have been constructed. Some of these are described at length in the articles under consideration. At Armstrong's, the substation contains seven 50-kw. transformers, each intended to receive single-phase current. They transform from 5,500 volts to 440, and are connected up in mesh. The motors used are of the induction type. At the North-Eastern Marine Engineering Co.'s works, the substation contains two 150-kw. synchronous motor-generators, receiving current at 5,500 volts, and generating continuous current at 250 volts. This substation contains a 7½-ton travelling crane. At Wigham, Richardson & Co.'s works, both continuous and alternating currents are distributed, and this station contains a 75-kw. asynchronous motor-generator. At the Northumberland Shipbuilding Co.'s Works, there is also a similar asynchronous motor-generator, and there are also four single-phase 75-kw. transformers, transforming from 5,500 to 440 volts. The motors here used are all of the induction type. The work to which these motors are applied in the different works is shown by means of various illustrations, and includes heavy work of all kinds. The article also contains several drawings, showing plan and cross-section of the main station and substations. W. H. S.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1822. *Polyphase Generators and Electric Traction.* **H. M. Hobart.** (Elect. Rev. 48. pp. 872–873, May 24, 1901.)—The author considers that practically all difficulties in the operation of rotary converters are due to the want of a sufficiently uniform angular velocity in the prime movers. With high-speed engines this lack of uniformity can be practically overcome without the provision of an excessively large flywheel, supposing the phase deviation allowable to be 2·5°, and the periodicity to be 25 cycles per second. But with slow-speed engines under the same conditions the flywheel becomes of enormous size, and the usual plan is to endeavour to prevent hunting by the addition of damping coils, or other devices. For slow-speed plant the author would recommend the use of a periodicity of, say, 8⅓ cycles, which would decrease the number of poles on the main generators and so indirectly assist the engines; but with this low periodicity, step-down transformers become very expensive. Under these conditions rotary converters should be abandoned, and synchronous motor generators substituted for them. The decreased efficiency of this arrangement as well as its greater cost will be to some extent counter-balanced by the decreased energy required to be expended in devices to prevent hunting, and by the simplification of the switchboard apparatus, as well as by other incidental modifications which would result in the employment of less skilled attendants in the substations. It may, however, still be advantageous to use rotary converters in connection with plants where the generators are direct connected to high-speed engines. W. H. S.

1823. *Polyphase Substation Plant.* **A. C. Eborall.** (Elect. Rev. 48. pp. 963–965, June 7; and 1009–1010, June 14, 1901.)—The author deals with the questions raised by Hobart. [See preceding Abstract.] He commences by giving a general outline of a specification for plant for a tramway scheme of not less than 6,000 h.p. He then proceeds to deal with Hobart's assertion that in order to prevent hunting of rotaries worked in connection with slow-speed generators, the flywheel effect in the generators must be very great, and considers that when this is the case it is due to defective design of the engines. To illustrate his point he quotes the case of a 5,000-h.p. engine running at 80 r.p.m., for which inquiries were made, the cyclic irregularity not to exceed 0·2 per cent. up or down. One English firm stipulated for 13,000 foot-tons as the flywheel effect; another required 8,000 foot-tons; while a Continental firm guaranteed a cyclic irregularity of 0·15 per cent. with a flywheel effect of 6,000 foot-tons, the engine offered having a lower guaranteed steam consumption than the others. It was indeed more expensive in itself, but with the added cost of heavier flywheel, the others came to about the same amount. The rest of the article is occupied with a discussion of the question of rotaries *v.* synchronous motor-generators. [See also Abstract No. 1802 (1901).] W. H. S.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

1824. *Uninsulated Returns on Tramway Systems.* **J. H. Rider.** (Electrician, 47. pp. 340–341, June 21, 1901. Paper read before the Incorporated Municipal Electrical Association, June, 19, 1901.)—The author discusses some points connected with the Board of Trade Regulations. These regulations provide for two separate earth connections to the negative terminal of the generator. One of these earth connections may be made by means of a water-pipe. At Plymouth, the shortest return feeder is 760 yards long, and the resistance between the rails and the earth connection, which is a water-pipe, was found to be about 0·5 ohm. It was found that 25 per cent. of the return current came back through the earth. The author considers that the regulations require revision, seeing that the obvious thing should be to make the resistance of the earth path as large as possible. This is simply done by removing the earth connection from the negative bus-bar. The author therefore holds that where the return conductor consists partly of uninsulated rails and partly of insulated cable, the earth connection should be made at the point where the insulated cable joins the rail, and not at the negative bus-bar. With more than one return feeder, negative boosters could be used to keep the points of earth connection at the rails at about the same potential. W. H. S.

1825. *Energy Consumed by Tramcars.* **E. Volkers.** (Elektrotechn. Zeitschr. 22. pp. 480–483, June 13, 1901.)—The author has conducted a series of experiments with a view to determining the amount of energy consumed by a tramcar under given conditions. The expenditure of energy may be considered as overcoming (1) friction, (2) wind pressure, (3) the force of gravity, in so far as there may be inclines on the road, and (4) the losses incurred by braking. The frictional losses were determined by running the car over a level stretch at very slow speeds, the current being switched off when a speed of 1 or 2 m. per second was reached; the rate at which the speed decreased was then noted. Under these conditions the resistance due to wind pressure was considered negligible. The resistance due to wind pressure was similarly calculated by running the car to and fro at different speeds in calm weather. The speed was determined by means of a Morse recorder, which was worked in connection with a contact-breaking device fitted on one of the wheels of the car. The frictional losses are very greatly increased if one wheel has a very slightly greater diameter than the other; moreover, the brake, if constructed so as to grip on the surface of the wheel, may on a dirty track cause frictional losses, even during the time when the car is supposed to be running freely. The frictional resistance of a certain car was found to be equivalent to 5 kg. per ton before leaving the sheds, but on returning after covering 20 kilometres on a fairly clean but wet track, the losses were found to have increased to 7·8 kg. per ton. The author gives figures showing the values of the resistance due to friction on various kinds of track. For that part of the weight which falls on the driving wheels, the resistance varies from 2·8 to 6·8 kg. per ton, according as the track is clean or dirty; for that portion of the weight which falls on the other axles, and for trailers, the figure varies from 1 to 5 kg. per ton. The wind pressure is difficult to calculate; the author uses the formula $P = 0{\cdot}1225Fv^2$, where P is the total pressure in kg., F is the perpendicular surface exposed in sq. m. (taken to be 7 for ordinary cars, and 2·5 for trailers), and v is the wind-velocity in metres per second. The main point is to determine the mean apparent velocity of the wind; the author gives figures for different cases. The work done against gravity is easily calculated in any case, but no allowance can be made for runs downhill, seeing that no energy is returned to the line. The losses due to braking can be reckoned by experimentally observing the speed at which the car would pass the stopping-place, supposing the brake had not been applied. These losses are often very serious, and depend to some extent on the skill of the driver. The overall efficiency of the motors and their gearing must also be ascertained, and it is necessary to take account of the fact that, at starting and during the time of getting up speed, the efficiency is very low. The author has found a mean overall efficiency of 60 per cent. with 4 stops per km., and a mean car-velocity of 12 km. per hour, the consumption of energy being noted by a Morse recorder placed in circuit with a Thomson meter and a contact-breaker fixed on a car-wheel, in addition to the speed recorder mentioned above. The article concludes with some numerical examples. It is pointed out that in practice much depends on the skill of the driver. At Copenhagen the cars, weighing 7 tons empty, take 400 watt-hours per car-kilometre, including 4 per cent. loss in feeders and the current used in lighting the cars, the measurements being made in the power-house. As the result of a competition, it was found that some drivers used only 255 watt-hours, while others used 350, the measurements in the competition being made on the car itself, and excluding the lighting current. W. H. S.

1826. *Rail-bonds.* **A. B. Herrick.** (Street Rly. Rev. 11. pp. 281–283, May, 1901.)—The contact surfaces should provide for a current-density not exceeding 90 amperes per square inch, and the surfaces should be under great pressure. Amalgamation of copper bonds is advantageous. Bonding should not be done in damp weather. Supplementary wires are far less efficient than the same amount of copper used in the bonds. Methods of practical testing are described, including one for locating faulty bonds by means of a car equipped with suitable apparatus. A. H. A.

1827. *Power Consumption of Cars equipped with Two and Four Motors.* **W. Pestell.** (Street Rly. Journ. 17. pp. 416–418 ; Discussion, pp. 419–421, May, 1901. Paper read before the New England Street Rly. Club, Feb. 28, 1901.)—The tests made by the author on the Lynn and Boston Railroad show that the power used in a four-motor closed car is greater than that used in a similar two-motor car by about 20 per cent. when motors of the same type and size are employed in each car. For open cars the power consumption is increased by 25 per cent., probably because the two extra motors become a greater proportion of the total load in this case. Under similar conditions a higher speed is always obtained with four motors, which accounts for part of the increase in the power used. The remainder must be due to motor losses and friction, the former being reduced to a minimum for the two motors, as they always run heavily loaded. A comparison of two G.E. 57 motors (52 h.p. each) and four G.E. 1,000 motors (37 h.p. each) shows but a very small difference in the power used, which appears to bear out the above assumption. The temperature of the motors in regular service was measured from time to time, and also a record made of the number of stops, time, power consumption, passengers carried, &c. It was found that the rise of temperature for a two-motor car was over 94° C. after running seven hours, but only 60° C. for a four-motor car after running eleven hours. The hottest place in the motor was found to be between the top field and the brush-holder yoke. The temperature was measured accurately to a fraction of a degree by an instrument similar to an ordinary platinum thermometer, except that iron wire was substituted for platinum in the thermometer coil, and a telephone receiver was used for determining the balance on the Wheatstone bridge.

Results obtained by Tests, February, 1900.

Length.	No.	Wheels.	Motors.	Watt-hours per Car-mile.	Trucks.
25-ft.	97	30 in.	2 G.E. 58	2,253	14-B. 3 Peckham
„	192	„	4 „ „	2,297·5	„ „
„	621	„	4 „ „	3,034	Laconia

Mean increase in power consumption by use of four motors = 24 per cent.

Results obtained on Closed-car Tests, 1899–1900.

25-ft.	169	30 in.	2 G.E. 58	2,573·8	14-B. 3 Peckham
„	97	„	2 „ „	2,247·2	„ „
„	156	„	4 „ „	2,907·1	„ „
„	128	„	4 „ „	3,013·3	„ „
„	97	„	4 „ „	3,036·7	„ „

Mean increase in power consumption by use of four motors = 24 per cent.

Results obtained on Open-car Tests, 1900.

12-bench open	744	30 in.	2 G.E. 67	1,997·6	Laconia.
„ „	738	„	2 „ „	1,828·2	„
„ „	740	„	4 „ „	2,546·8	„
„ „	759	„	4 „ „	2,425·4	„

Increase in power consumption of four-motor cars over two = 30 per cent.

Comparative Test of 25-ft. Closed Cars. Watts per Car-mile.

	No. 801. 2 G.E. 1,000	No. 397. 2 G.E. 1,000	No. 801. 4 G.E. 1,000	No. 397. 2 G.E. 57
W. Lynn to Revere St.......	1,993	1,956	1,984	2,017
Revere St. to Vine St.	2,133	2,209	2,120	2,108
Vine St. to Vine St.	2,491	2,740	2,700	2,558
Vine St. to Revere St.	2,235	2,178	2,555	2,356
Revere St. to W. Lynn......	1,422	1,602	1,934	1,848
W. Lynn to W. Lynn, *viâ* Swampscott..................	2,717	2,311	2,461	2,340
Total.........	12,991	12,996	13,754	13,227
Average ...	2,165	2,166	2,292	2,204
Total number of trips	4	4	7	8
„ „ of passengers	390	490	694	952
Number of passengers per round trip	97	122	99	119

Car No. 397 was equipped with Peckham truck, 4-ft. wheel base, 33-in. wheels. Car No. 801, Bemis truck, 5-ft. wheel base, 30-in. wheels. Car No. 801, when running with two motors, was equipped with one motor on each truck, on axles nearest the centre of car. Car No. 397, when running with two motors, was equipped with one motor on each truck on axles nearest the ends of the car, with motor suspended between axle and end frame of truck.

Curves for three trial runs are given in the paper, and show the kw.-hours per car-mile, temperature of motors, number of passengers, number of stops, and time. These curves show that the power consumed depends much more on the number of stops made than on the speed.

Discussion.—**Pestell** thought it was shown that two motors, even of small size, are more economical in every way except in repairs, the chief objection to their use being their smaller tractive power. He thought that if some method could be devised—increase of copper or better ventilation—of keeping down the rise of temperature in motors, it would be a great advantage to be able to get a greater amount of work for the same dead-weight carried. **Goss** found that cars with four motors gave no trouble on hills which two-motor cars were not able to climb owing to leaves on the track. J. H.

1828. *Power Consumption of Cars equipped with Two and Four Motors.* **C. H. Bigelow.** (Street Rly. Journ. 17. pp. 418–419; Discussion, pp. 419–421, May, 1901. Paper read before the New England Street Rly. Club, Feb. 28, 1901.)—The results of the tests given in this paper are similar to those given in the preceding Abstract. The author considers the four-motor equipment unsuitable for service on the Boston Elevated Railway Company's system, and does not think that the use of four motors will reduce the cost of maintenance. J. H.

1829. *Diameter of Wheels for Automobiles.* **M. Luxenberg.** (Centralblatt für Accumulatoren, 2. pp. 161–164, June 1, 1901.)—A continuation of the discussion of this question. [See Abstracts Nos. 587 and 1886 (1901).] The experiments which were carried out by Morin in 1840 are quoted, and tend to show that the formula proposed by Müller does not hold good under all conditions. W. H. S.

ELECTRIC LAMPS AND LIGHTING.

1830. *Vapour Lamps.* **P. Cooper Hewitt.** (Elect. Rev. N.Y. 38. pp. 513–515, April 27, 1901; and Elect. World and Engineer, 37. pp. 679–681, April 27, 1901.)—The paper contains illustrations of different forms of the lamp, which consists of a tube with sealed-in electrodes, one of which is immersed in a liquid, the surface of the liquid thus forming the electrode in the tube. Curves of measurements taken with the lamps are given, showing that the vapour column approximately follows Ohm's law; efficiencies of 0·32 watt per candle were obtained. G. H. B.

1831. *Cheap Method of Reducing Candle-Power of Lamps.* **P. Stern.** (Elektrotechn. Zeitschr. 22. pp. 451–452, May 30, 1901.)—Instead of using a resistance for reducing the candle-power—an arrangement which results in poor efficiency in so far as the production of light is concerned—the author uses a two-way switch by means of which an auxiliary lamp may be connected in series with the main lamp. This auxiliary lamp is so chosen as to be fully incandesced when joined in series with the other. The most economical arrangement is obtained when the auxiliary lamp is supplied at half the p.d. of the mains. A. H.

1832. *Incandescent Lamp in Practice.* **F. W. Willcox.** (Elect. World and Engineer, 37. pp. 897–899, May 25, 1901. Abstract of paper read before the National Electric Light Association.)—The author deals generally with the construction and characteristics of American incandescent lamps and emphasises the importance of free renewal by the supply authority; it is

stated that this costs about 0·2d. per kilowatt-hour sold. The whole of the lamps should be regularly removed and tested and the bad ones replaced.
A. H. A.

1833. *Electric Stage-Lighting.* **A. Bainville.** (Électricien, 21. pp. 212–216, April 6; 257–268, April 27; and 291–298, May 11, 1901.)—In this paper the Mornat and Langlois system, which is in use at the Opera, is first described. In this arrangement a series of variable resistances is connected up to a rectilinear commutator over which a contact-piece is moved by a motor, so that any predetermined series of variations of light can be reproduced automatically when the motor is started.

The other system is due to the Compagnie Générale d'Éclairage et de Force (a. é. Clémançon) and enables the lighting to be controlled from the stage itself. The resistance wires are wound on horizontally arranged drums dipping into mercury-baths. These drums are rotated slowly by separately excited motors which are themselves controlled by means of a shaft rotated slowly by a motor, and bearing a number of discs to the sides of which pins can be secured in any desired positions. The pins of each disc act on the ends of a rocking arm mounted on the same shaft as the bridge-piece of a mercury reversing-switch which, when in its normal horizontal position, also short-circuits the armature of one of the motors driving the resistance drums. By suitably setting the pins in the several discs any desired cycle of changes in the light can be performed automatically. C. K. F.

REFERENCES.

1834. *Design for Distributing Networks.* **C. A. Gillin.** (Elect. Engin. 26. pp. 764–766; 798–799; and 834–836, 1900.)—Notes on design having regard to—(1) uniformity and variation of pressure; (2) breakdowns; (3) localisation of faults.
W. R. C.

1835. *Falk Joint.* **Pédriali.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 524–534; Discussion, pp. 534–536, Feb. 7, 1901.)—A detailed description of the methods used.
E. H. C.-H.

1836. *Underground Cables.* **A. Devey.** (Elect. Rev. 48. pp. 605–606, April 5, and p. 645; with Discussion, pp. 645–647, April 12, 1901. Abstract of paper read before the Glasgow Section of the I.E.E., March 13, 1901.)—Some notes on the various systems of laying underground cables. W. H. S.

1837. *Safety Regulations for Overhead Trolley Systems.* **J. Heitzinger.** (Zeitschr. Elektrotechn., Wien, 19. pp. 211–212, April 28, 1901.)—An account of the regulations recently adopted in Vienna regarding the protection of telegraph and telephone wires against accidental contact with an overhead trolley-wire. A. H.

1838. *Working Expenses of Electric Railways.* (Tram. Rly. World, 10. pp. 174–177, April, 1901.)—Statistics, extending in some cases over a series of years, are given relating to British Railways, including the Liverpool Overhead Railway, the City and South London Railway, the Glasgow Subway, and the Central London Railway.

1839. *Electric Cabs in Paris.* **H. E. P. Cottrell.** (Feilden, 4. pp. 513–530, May, 1901.)—An account of the electric cabs which were running recently in Paris.
W. R. C.

1840. *Electric Automobiles* v. *Tramcars.* **A. D. Adams.** (Cassier, 19. pp. 443–448, April, 1901.)—The author considers the possibility of running electric automobiles more cheaply than electric tramcars. W. R. C.

1841. *Transmission and Spring Suspension of Electric Automobile Motors.* (Horseless Age, 8. pp. 62–65, April 17, and 109–110, May 1, 1901. From a paper by **R. Conrad** in the Motorwagen.)—A number of different systems are described and illustrated, together with comments on the merits and demerits of each of them and on the general principles involved. E. J. W.

1842. *Sprague Multiple-unit System.* **F. J. Sprague.** (Street Rly. Journ. 17. pp. 371–384, May, 1901.)—A full description of this system with diagrams of wiring and illustration of each piece of apparatus. E. H. C.-H.

1843. *Electricity* versus *Steam for Heavy Railway Service.* **L. D. Tandy.** (Tram. Rly. World, 10. pp. 219–226, May 9, 1901.)—Comparative figures are given concerning six branch lines of a large American Railway Company, showing the calculated costs when electrically worked as against present costs with steam. E. H. C.-H.

1844. *Graphical Treatment of Traction Problems.* **P. Pforr.** (Elektrotechn. Zeitschr. 22. pp. 411–415, May 16, 1901.)—The author traces out the analogy between a loaded beam and an overhead conductor from which current is tapped at various points, and shows how the funicular polygon may be applied to the investigation of problems regarding the fall of potential along an overhead trolley wire. A. H.

1845. *Krizik's Block-Signalling System.* **A. Prasch.** (Zeitschr. Elektrotechn., Wien, 19. pp. 259–261, May 26; and 269–274, June 2, 1901. Paper read before the Elektrotech. Verein, April 3, 1901.)—The apparatus described here is substantially the same as that in Abstract No. 2091 (1900), but a number of diagrams are given showing modified arrangements of the circuits. C. K. F.

1846. *Regulation of a Three-Phase Power Transmission Line.* **F. G. Baum.** (Elect. World and Engineer, 37. pp. 822–824, May 11, 1901.)—In a paper by the author and F. A. C. Perrine [see Abstract No. 2325 (1900)], an analytical investigation was given of the problem of power transmission by means of overhead wires. An equation was found which enabled the voltage at the generator terminals to be calculated for any load and any power-factor. In this paper a graphical interpretation is given of the equation, and it is shown that it is equivalent to a simple diagram which can be usefully employed for predetermining the regulation on any particular transmission line. The diagram is applicable to any alternating current system of transmission. Numerical examples illustrating this method are completely worked out for two separate three-phase systems, one 15 and the other 150 miles long. The diagrams show at a glance what the generator voltage is for various loads on the motors at the far end of the lines. A. R.

1847. *Barnes Electricity Works.* (Elect. Rev. 48. pp. 933–935, May 31, 1901.)—A short description of this station, which supplies current on the continuous-current system. The engine-room contains two 150-kw. dynamos, the boilers supplying superheated steam. W. H. S.

1848. *Chandiere Falls Power Transmission.* **R. Girouard.** (Elect. World and Engineer, 37. pp. 1009–1011, June 15, 1901.)—This scheme utilises the power developed by a waterfall, 115 feet high, about 9 miles from Quebec.

TELEGRAPHY AND TELEPHONY.

1849. *Alternating Currents in Telegraphy.* **J. Piérart.** (Soc. Belge Élect., Bull. 17. pp. 485–493; Discussion, pp. 493–495, 1900.)—This paper treats of Delany's, Crehore and Squier's, and Rowland's systems. In Delany's chemical telegraph the Morse code is employed and the contacts in the transmitter take place through a tape perforated similarly to that of a Wheatstone. One brush operates through the series of holes on one side of the tape, and the other acts similarly on the other side; a positive battery transmits in the first case, and a negative in the second. At the receiving end three iron styles or pens press upon a paper tape which is saturated with cyanide of potassium. The middle style is connected to line, the two outer to earth. A positive current coming from line causes the former to stain the tape, while one coming from earth causes the outer styles to mark. Points are counted on the middle line and the double marks from the outer styles are counted as bars. Hence the usual signals can be composed. A speed of 8,000 words per minute has been obtained in the laboratory, but for 800 kilom. of actual line 1,000 words.

The author gives credit to Crehore and Squier for first utilising a sinusoidal current for telegraphy, and a description is given of the system. [See Abstract 1969 (1900).] Finally the author describes Rowland's system.
E. O. W.

1850. *Röder-Oprendak's Loud-speaking Microtelephone.* **W. Krejsa.** (Zeitschr. Elektrotechn. Wien, 19. pp. 312–313, June 23, 1901. Paper read before the Elektrotechn. Verein, Vienna, April 10, 1901.)—The feature of this arrangement is a special form of induction coil for use in the usual manner, *i.e.*, with the microphone and a battery in a local circuit including the primary of the induction coil. This induction coil consists of an oblong core of laminated iron divided to form two horse-shoes, one of which is fixed and the other is supported in a guide and held with its ends at a short distance away from the fixed horse-shoe by means of a spring. The movable core or armature is provided with an additional coil through which a current is passed from a battery, which polarises the armature, so that its two poles are opposite unlike poles of the fixed horse-shoe. Actual contact of the poles is prevented by inserting a piece of non-magnetisable metal between them. This arrangement causes the variations of current in the primary to be intensified in the secondary and the loudness of the sounds emitted by the receiver to be increased without interfering with the clearness. C. K. F.

1851. *Wireless Telephony.* **E. Wilson** and **C. J. Evans.** (Electrician, 47. p. 46, May 3, 1901.)—The current from a telephone transmitter energises a small electromagnet which is placed with its poles one on either side of an electric arc. In circuit with the arc is a coil 4 feet in diameter, consisting of forty turns of No. 18 S.W.G. cotton-covered copper wire. The receiver may be another such coil with a telephone receiver in circuit, or it may have an arc in circuit instead of the telephone, in which case a rubber tube fitted to the hollow carbon conveys the sounds produced in the receiving arc to a microphone and telephonic receiver. J. E.-M.